



88064976

PUBLIC INSPECTION COPY
PLEASE RETURN TO:
Area Oil Shale Office
U.S. Geological Survey
131 North 6th St. Suite 300
Grand Junction, CO 81501

EDWIN C. HERRMAN
ENVIRONMENTAL PROTECTION AGENCY

OIL SHALE TRACT C-b

ENVIRONMENTAL AND EXPLORATION PROGRAM

SUMMARY REPORT #2

(Through February 28, 1975)

C-b SHALE OIL PROJECT

Ashland Oil, Inc.
Atlantic Richfield Company, Operator
Shell Oil Company
The Oil Shale Corporation

TN
637
CA9
03747
VOL. 2
P. 2

10 880 6 49 76

TN
859
.C64
C3747
10.2
C.3

U. S. DEPARTMENT OF THE INTERIOR
PROTOTYPE OIL SHALE LEASING PROGRAM

TRACT C-b

SUMMARY REPORT #2

(Through February 28, 1975)

**BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047**

Submitted to:

Mr. Peter A. Rutledge
Area Oil Shale Supervisor
Conservation Division
U. S. Geological Survey
Grand Junction, Colorado

By:

C-b Shale Oil Project

Ashland Oil, Inc.
Atlantic Richfield Company, Operator
Shell Oil Company
The Oil Shale Corporation

Two Park Central, Suite 555
1515 Arapahoe Street
Denver, Colorado 80202

April 23, 1975

1771-1775
05 April 1775 - 1775
1775-1776
1776-1777
1777-1778
1778-1779

TRACT C-b
SUMMARY REPORT #2
(Through February 28, 1975)

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION.	1
I. PRE-EXPLORATION ENVIRONMENTAL RECONNAISSANCE SURVEYS.	2
II. ENVIRONMENTAL BASELINE MONITORING PROGRAMS.	4
A. Surface Water	4
1. Surface Streams	4
2. Springs and Seeps	4
B. Core Drilling and Associated Ground Water	11
1. Well Survey Plats	11
2. Completion Data	11
3. Drilling Water Production	11
4. Water Quality - Drilling.	11
5. Water Quality - Baseline.	25
6. Water Quality - Aquifer Pump Tests.	25
7. Aquifer Data - Jetting Tests.	29
8. Aquifer Data - Drill Stem Tests & Multi-Packer Tests.	29
9. Aquifer Data - Pumping Tests.	34
10. Lithologic Log Data	46
11. Geophysical Log Data.	46
12. Core Assay Data	46
13. Core and Cuttings Trace Element Analysis.	49
14. Rock Mechanics.	49
15. Gas Determination and Analysis - Tract C-b Gas Sampling Program.	49
C. Air Quality	53
1. Air Quality and Surface Meteorology	53
2. Low Altitude Meteorology.	71
3. Upper Air Studies	71
4. Visibility.	74
5. Atmospheric Diffusion Studies	74

TABLE OF CONTENTS (continued)

	<u>Page</u>
II. ENVIRONMENTAL BASELINE MONITORING PROGRAMS (continued)	
D. Biology.	79
1. Terrestrial Wildlife Studies	79
2. Aquatic Studies.	83
3. Terrestrial Vegetation Studies	93
4. Dendrochronology and Dendroclimatology Studies . . .	97
5. Soil Survey and Productivity Assessment Studies. . .	97
III. OTHER STUDIES.	125
A. Fish and Wildlife Management Plan.	125
B. Revegetation Studies	126
C. Micro-Environmental Studies.	127
D. Aerial Photographic Studies.	128
E. Archaeological Studies	129
F. Scenic Values Study.	133

TRACT C-b
SUMMARY REPORT #2
(Through February 28, 1975)

LIST OF FIGURES

<u>Title</u>	<u>Fig. No.</u>	<u>Page</u>
Preliminary Isopach of Over Burden, Surface-Mine	II B-1	15
Cross Section, Tract C-b	II B-2	16
AT-1 Production Water Graph	II B-3	17
Temperature, Conductivity & Production, SG-1	II B-4	18
Temperature, Production and Conductivity, SG-1a	II B-5	19
Temperature, Production and Conductivity, SG-17	II B-6	20
Temperature, Conductivity & Production, SG-20	II B-7	21
Temperature, Conductivity & Production, SG-21	II B-8	22
East-West Water Production Cross-Section	II B-9	23
North-South Water Production Cross Section	II B-10	24
Pump Test, Aquifer Pad	II B-11	40
Schematic Cross-Section Upper Aquifer Pump Test	II B-12	42
C-b Shale Oil Project Air Quality and Meteorological Monitoring Sites	II C-1	54
Diurnal Variations in Wind Velocity	II C-2	67
Horizontal Temperature Variations in Piceance Creek, 29 January 1975	II C-3	70
Wind Roses At the Meteorological Tower (100')	II C-4	72
Variation of Wind Velocity with Height on the Meteorological Tower	II C-5	73
C-b Temperature Profile	II C-6	75
Comparison of Temperature Profiles at C-a and C-b	II C-7	76

LIST OF FIGURES (continued)

<u>Title</u>	<u>Fig. No.</u>	<u>Page</u>
Distribution of Deer During December 1974 and January 1975	II D-1	80
Distribution of Deer During Late February 1975	II D-2	81
Length-Frequency Distribution of Brook Trout Captured in the Piceance Basin over Three Sampling Period: September and November 1974 and January 1975	II D-3	87

TRACT C-b
SUMMARY REPORT #2
(Through February 28, 1975)

LIST OF TABLES

<u>Title</u>	<u>Table No.</u>	<u>Page</u>
Status of Pre-Exploration Environmental Investigations - 4/1/75	I-1	3
Piceance Creek Below Rio Blanco, U.S.G.S. No. 09306007, October 1974 - February 1975	II A-1	5
Stewart Gulch Ab West Fork Nr Rio Blanco, U.S.G.S. No. 09306022, October 1974 - February 1975	II A-2	6
West Fork Stewart Gulch Near Rio Blanco, U.S.G.S. No. 09306025, October 1974 - February 1975	II A-3	7
Cottonwood Gulch Near Rio Blanco, U.S.G.S. No. 09306039, December, 1974	II A-4	8
Willow Creek Near Rio Blanco, U.S.G.S. No. 09306058, October 1974 - February 1975	II A-5	9
Piceance Creek Ab Hunter Creek, Nr. Rio Blanco, U.S.G.S. No. 09306061, October 1974 - February 1975	II A-6	10
Well Summary Table	II B-1	12
Water Quality Samples - Jetting Tests and Drill Stem Tests	II B-2	26
Water Quality Samples Collected During the Drilling of SG-17	II B-3	27
Water Quality Analysis - Aquifer Pump Tests, AT-1	II B-4	28
Jetting Test Data	II B-5	30
Summary of Drill Stem Test Intervals, Boreholes SG-17, SG-20, and SG-21	II B-6	31
Summary of Multiple Packer Test Intervals, Borehole SG-17	II B-7	33
Horizontal Permeability Calculations, SG-17 Drill Stem Tests	II B-8	35

LIST OF TABLES (continued)

<u>Title</u>	<u>Table No.</u>	<u>Page</u>
Horizontal Permeability Calculations, Tract C-b, Multi-Packer Tests	II B-9	37
Horizontal Permeability Calculations, Tract C-b, SG-20	II B-10	38
Aquifer Test Observation Well Data	II B-11	44
Transmissivity and Storage Coefficients, Shallow Aquifer	II B-12	45
Lithologic Logs	II B-13	47
Geophysical Logs	II B-14	48
Assay Data	II B-15	50
Air Quality Summary, September 1974 - November 1974, Trailer No. 020	II C-1	56
Air Quality Summary, September 1974 - November 1974, Trailer No. 021	II C-2	57
Air Quality Summary, September 1974 - November 1974, Trailer No. 022	II C-3	58
Air Quality Summary, September 1974 - November 1974 Trailer No. 023	II C-4	59
Air Quality Summary, September 1974 - November 1974 Trailer No. 024	II C-5	60
Air Quality Summary, December, 1974, Trailer No. 020	II C-6	61
Air Quality Summary, December, 1974, Trailer No. 021	II C-7	62
Air Quality Summary, December, 1974, Trailer No. 022	II C-8	63
Air Quality Summary, December, 1974, Trailer No. 023	II C-9	64
Air Quality Summary, December, 1974, Trailer No. 024	II C-10	65
Frequency Distribution of Particulate Concentrations, September 1974 - November 1974	II C-11	66
Representative Variability in Wind Direction, Trailer No. 021, Monthly Mean Values for November, 1974	II C-12	69

LIST OF TABLES (continued)

<u>Title</u>	<u>Table No.</u>	<u>Page</u>
Atmospheric Stability Assessment - Comparison	II C-13	78
Mean Lengths and Weights of Fish Captured During September 1974	II D-1	84
Mean Lengths and Weights of Fish Captured During November 1974	II D-2	85
Mean Lengths and Weights of Fish Captured During January 1975	II D-3	86
Soerensen's Index of Similarity (K) of Species of Fish Between Stations	II D-4	88
Number of Benthic Individuals and Species at Each Biological Sampling Station for Piceance Creek During November and December 1974 and January 1975	II D-5	89
Number of Benthic Individuals and Species at Each Biological Sampling Station for Willow Creek and Lakes During November and December 1974 and January 1975	II D-6	90
Number of Benthic Individuals and Species at Each Biological Sampling Station for White River During November and December 1974 and January 1975	II D-7	91
Number of Benthic Individuals and Species at Each Biological Sampling Station for Stewart Creek and Lakes During November and December 1974 and January 1975	II D-8	92
Estimates of Periphyton Mean Biomass (gm/m^2) Based on Three Replicate Samples at Each Station for September, October and November 1974	II D-9	94
Microbiology of Piceance Creek, Stations 1 through 7, Taken in November and December 1974 and January 1975	II D-10	95
Microbiology of the White River, Station 1 and 2, Taken in November and December 1974 and January 1975	II D-11	96

LIST OF TABLES (continued)

<u>Title</u>	<u>Table No.</u>	<u>Page</u>
Life Form Spectrum of Species on Tract C-b	II D-12	98
Abbreviations of Life Forms of Plants Used in Describing the Flora of Tract C-b	II D-13	99
Summary of the Geographical Distribution of the Species Present in the Flora of Tract C-b	II D-14	100
Annotated Vascular Flora for Tract C-b	II D-15	101
Alphabetical Listing of Common Names for the Flora of Tract C-b	II D-16	118

INTRODUCTION

This Summary Report #2 presumes that the reader has read or has access to the Tract C-b Summary Report #1 (submitted to the U.S.G.S. Area Oil Shale Supervisor on February 10, 1975); the descriptions of the type of data collected and manner of collection that were included in the earlier report are not duplicated in this one. Rather, the focus of this report is shifted from program description to actual summarization of the data and preliminary conclusions where appropriate. Of course, in those few instances where a new type of data is reported, a description of the data collection procedures is given.

Summary Report #2 is an overview of the thirteen-volume Quarterly Report #2. The full Quarterly Report is an assemblage of the environmental and exploration data received during the Winter Quarter of December 1974 through February 1975 (including some data from work preceding this quarter that suffered a time lag in analysis and reporting). Quarterly Report #2 was submitted to the Area Oil Shale Supervisor on April 14, 1975, and parties interested in more in-depth data review than can be accomplished through this summary report are referred to the Area Oil Shale Supervisor. Following the pattern of the first summary report, Summary Report #2 is organized in sections that are consistent with Quarterly Report #2. For example, if more information is desired on drill stem and multi-packer tests than is available in Section II B-8 of this report, then the full set of data sheets in Section II B-8 of Quarterly Report #2 may be examined.

The Tract C-b Lessees reiterate the position stated in the previous summary report that any suggestions based upon this early dissemination of data are welcome for the purpose of helping to achieve the objectives intended by the U. S. Department of the Interior Prototype Oil Shale Leasing Program.

PRE-EXPLORATION ENVIRONMENTAL RECONNAISSANCE SURVEYS

Pre-exploration environmental reconnaissance surveys, as described in Summary Report #1, are conducted by a team of experts in the fields of plant ecology, animal ecology, archaeology and, as needed, aquatic ecology. These surveys are conducted prior to any appreciable disturbance of the Tract C-b area for the purpose of 1) ensuring that activities are not planned in significant habitat, vegetation, or archaeological areas, and 2) providing a record of existing conditions for use in later rehabilitation of the disturbed areas.

*Heater
approved
archaeology*

The only reconnaissance work required during this quarter for areas of potential ground disturbance was for the drilling of slant core holes. Reports from these investigations, insofar as they have been completed, are included in the C-b Shale Oil Project Quarterly Report #2. Where investigations have not yet been performed because of snow conditions, the planned exploration activities have been postponed until these investigations are completed and any recommendations made by the investigators are evaluated. The present status of these slant core hole investigations is shown at the bottom of Table I-1.

TABLE I-1

STATUS OF PRE-EXPLORATION ENVIRONMENTAL INVESTIGATIONS - 4/1/75

<u>LOCATION</u>	ARCHAEOLOGICAL EVALUATION	PLANT, ANIMAL, AND AQUATIC EVALUATION
Coreholes SG-1 through SG-21 and Roads	X	X
Surface Water Stations 1 through 13	X	---1
Support Facilities	X	X
Air Quality Sites (5) and Meteorological Tower	X	X
Alluvial Wells ("A" Series) 1 through 13	X	X
Relocation of Coreholes SG-6 and SG-7	X	X
Relocation of Corehole SG-17	X*	X
Relocation of Roads to SG-4 and SG-17	X	X
Biological Observation Plots	X*	X*
Powerlines	X	---2
Old Coreholes Cb-1, Cb-2, Cb-3, and Cb-4	X*	X
Old Coreholes 71-1, 71-2, 71-3, TG2-1, TG3-2 & Fed 2-b	X	X
Road to SG-18 ("CH-18")	X	X
Area Surrounding Aquifer Test Site	X	X
Road from Piceance Creek to Cottonwood and Sorghum Gulches	X	X
Road from Piceance Creek to Tract	X	---3
Road between Cottonwood and Sorghum Gulches	X	X
Slant Hole Drill Sites NQ22A (#1), SG-22 (#2), NQ22 (#3), NQ4 (#4), NQ7 and NQ12	X ⁴	X

- * evaluation received through verbal communication; no written report
- 1 installed by USGS prior to biological reconnaissance; minimal disturbance
- 2 minimal biological disturbance
- 3 judgment that improvement of already heavily-travelled road would not result in increase in biological disturbance
- 4 waiting for field examination on SG22

ENVIRONMENTAL BASELINE MONITORING PROGRAMS

II A SURFACE WATER

II A-1 Surface Streams

During the second quarterly report period, water samples were obtainable from six of the thirteen stations on and near Tract C-b (Tables II A-1 through II A-6). A separate set of samples was also collected from the four major stations by the U.S.G.S. during the week of December 4, 1974, and forwarded to Denver for analysis of organic components. Most of the stations remained dry, however, although a considerable quantity of snow fell during the reporting period. Snow surveys are underway, and a summary of the results will be available later in the spring. Weather conditions were quite severe at times and temperatures reached -52° F. at the Rock School meteorological station. As a result, many of the streams were frozen over, and automated measurements were difficult, if not impossible to obtain.

The data from U.S.G.S. Station No. 09306039 Cottonwood Gulch near Rio Blanco (Table II A-11 on page 8) represent the discharge water from the upper zone aquifer pumping test of AT-1. The test well is located approximately two miles up the gulch and was discharging approximately 1 cfs from the well head at the time. The loss in water (.38 cfs at the gauging station vs. 1 cfs at the well head) occurred because water seeped into the two mile stretch of dry stream bed.

*unreported*II A-2 Springs and Seeps

Water quality samples from all springs and seeps adjacent to Tract C-b were collected and analyzed during the first quarterly report period, and the analytical data were included in the first report. The ground temperatures were generally cold throughout the second quarterly period, with the result that many of the seepage areas were covered by snow or were frozen. It is planned that at least one additional water quality sampling run on springs and seeps will be conducted in April or May; results from that sampling run will be included in a subsequent quarterly report.

not specifically required.

TABLE II-A-1
 PICEANCE CREEK BELOW RIO BLANCO
 U.S.G.S. NO. 09306007
 OCTOBER 1974 - FEBRUARY 1975

	10/4	10/9	10/16	10/23	10/31	11/6	11/20	12/4	12/18	12/31	1/15/75	2/3	
(*)1. Alkalinity (mg/l)	440	462	449	445	478	472	430	424	442	454	453	461	
(*)2. Aluminum (ug/l)								450					
3. Aromatics, Polycyclic													
4. Arsenic (ug/l)	2	3	2	1	1	2	4	3	3	1	1	5	
5. Barium (ug/l)	0	<100	100	0	100	<100	<100	130	100	100	0	100	
(*)6. Beryllium (ug/l)								<1					
7. Bicarbonate (mg/l)	537	563	548	542	583	576	524	517	539	554	552	562	
(*)8. Bismuth (ug/l)								<5					
9. Boron (ug/l)	260	290	200	280	190	250	230	130	220	210	240	190	
10. Cadmium (ug/l)	<1	<1	0	0	0	1	0	<15	0	0	2	0	
11. Carbonate (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	
(*)12. Carbon Dioxide (mg/l)							8.4	5.2	3.4	4.4	7.0	.9	
13. Chloride (mg/l)	16	17	16	16	15	16	16	13	15	14	16	19	
14. Chromium (ug/l)								<5	0	0	10	0	
(*)15. Cobalt (ug/l)								<5					
16. COD								9					
17. Coliform, Total & Fecal													
18. Color								5	2	3	5	3	
19. Conductivity, Specific (uM)	1140	1190	1160	1160	1180	1200	1090	1070	1200	1100	1200	1120	
20. Copper (ug/l)	1	6	0	0	1	2	1	1	1	0	8	1	
21. Cyanide (mg/l)								.00	.00	.00	.00	.00	
22. Discharge (CFS)	--	2.9	4.1	5.3	--	6.0	9.5	9.8	11	7.8	9.5	12	
23. Dissolved Oxygen													
24. Fluoride (mg/l)	1.1	1.1	1.0	1.2	1.0	1.0	1.0	1.1	1.0	1.1	1.2	1.1	
(*)25. Gallium (ug/l)								<3					
(*)26. Germanium (ug/l)								<5					
(*)27. Hardness (Ca, Mg) (mg/l)	370	350	380	360	400	360	350	330	390	360	370	370	
(*)28. Hardness, Non-Carbonate (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	
29. Iron (ug/l)	30	60	60	80	40	390	10	300	10	10	20	20	
30. Kjeldahl Nitrogen								.30	.33	.25	.48	.61	
31. Lead (ug/l)	0	4	3	1	1	3	2	<5	1	0	7	6	
32. Lithium (ug/l)	0	0	0	0	0	0	0	8	20	20	20	20	
33. Magnesium (mg/l)	49	43	50	46	50	42	42	45	48	43	46	46	
34. Manganese (ug/l)	100	170	160	140	230	230	110	100	80	50	60	67	
35. Mercury (ug/l)	.0	.0	.0	.0	.0	.0	.0	<.1	<.1	.0	.1	.1	
(*)36. Molybdenum (ug/l)								7					
(*)37. Nickel (ug/l)								<4					
38. Nitrate (mg/l)	.07	.03	.02	.00	.04	.07	.26	.38	.33	.43	.56	.32	
39. Nitrite (mg/l)								.00	.02	.00	.01	.01	
40. Odor													
41. Oil & Grease								0	1	1	8	6	
42. Ortho-Phosphate (mg/l)	.00	.03	.00	.00	.09	.09	.03	.06	.09	.15	.06	.12	
(*)43. Ortho-Phosphorus (mg/l)	.00	.01	.00	.00	.03	.03	.01	.02	.03	.05	.02	.04	
44. Pesticides													
45. pH								8.2	8.4	8.3	8.1	9.0	
46. Potassium (mg/l)	2.8	3.1	3.3	3.5	3.8	3.8	2.9	2.4	2.9	2.9	3.4	2.6	
47. Selenium (ug/l)	1	0	0	0	0	0	1	1	2	1	1	1	
48. Silica (mg/l)	17	17	17	16	18	16	15	15	3.4	16	17	16	
(*)49. Silver (ug/l)								0					
50. Sodium (mg/l)	140	150	140	130	140	140	130	120	130	120	130	130	
(*)51. Sodium Adsorption Ratio	3.2	3.5	3.1	3.0	3.1	3.2	3.0	2.9	2.9	2.8	2.9	2.9	
(*)52. Sodium (%)	45	48	44	44	43	46	44	44	42	42	43	43	
53. Solids, Dissolved (mg/l)	730	749	738	718	762	739	698	664	715	697	723	736	
54. Solids, Suspended													
(*)55. Strontium (ug/l)								1800					
56. Sulfate (mg/l)	170	170	170	170	170	160	160	150	170	150	160	170	
57. Sulfide								.0	.5	.9	.0	.1	
58. Temperature (°C)	13.0	14.0	13.0	11.0	5.0	5.0	4.0	4.0	.0	1.0	1.0	1.0	
(*)59. Tin (ug/l)								<5					
(*)60. Titanium (ug/l)								25					
61. Turbidity								20	20	6	30	10	
(*)62. Vanadium (ug/l)								<3.0					
63. Zinc (ug/l)	20	60	30	0	30	30	10	<15	0	10	40	20	
64. Zirconium (ug/l)								<10					
65. Calcium (mg/l)	69	69	70	68	76	75	71	58	76	73	74	72	
66. Complete Element Scan													
67. Radioactivity													
Gross Alpha (pCi)													
Radium 226*													
Gross Beta													
Thorium 230**													
Uranium **													
68. Total Organic Carbon (TOC)													
If TOC > 10 mg/liter, then													
Nitrogen (Base Extraction)													
Organic Carbon, Dissolved													
Organic Carbon, Suspended													
Phenols													
Sulfur (Acid Extraction)													

.5mg/L

20 mg/L

was not tested per.

(*) Not Required

* Required if Gross Alpha > 4 picocuries per liter (pCi)
 ** Required if Gross Beta > 100 picocuries per liter (pCi)

N Non-Instantaneous Discharge

NOTE: A number preceded by a less than (<) sign represents the lowest detectable limit for the analytical method used for that particular sample run. Analytical method and thus lower limit may change across sample runs even for a single element.

TABLE II-A-2
STEWART GULCH Ab WEST FORK Nr RIO BLANCO
U.S.G.S. No. 09306022
OCTOBER 1974 - FEBRUARY 1975

	10/4	10/9	10/16	10/23	10/30	11/6	11/20	12/4	12/17	12/30	1/15/75	2/3		
(*)1. Alkalinity (mg/l)	387	404	396	422	421	436	641	403	472	405	418	426		
(*)2. Aluminum (ug/l)														
3. Aromatics, Polycyclic														
4. Arsenic (ug/l)	1	1	1	1	0	1	4	1	2	0	1	3		
5. Barium (ug/l)	0	<100	<100	0	<100	<100	<100	<100	100	<100	100	<100		
(*)6. Beryllium (ug/l)														
7. Bicarbonate (mg/l)	472	492	483	514	513	531	782	491	575	494	510	519		
(*)8. Bismuth (ug/l)														
9. Boron (ug/l)	110	100	50	110	30	120	530	90	260	80	120	70		
10. Cadmium (ug/l)	0	<1	0	0	0	3	0	1	1	0	1	1		
11. Carbonate (mg/l)								0	0	0	0	0		
(*)12. Carbon Dioxide (mg/l)								3.9	3.7	5.0	5.1	1.3		
13. Chloride (mg/l)	6.5	6.3	6.0	6.6	6.1	6.9	16	6.5	11	7.6	6.7	7.0		
14. Chromium (ug/l)								<10	<10	0	10	0		
(*)15. Cobalt (ug/l)														
16. COD								5	--					
17. Coliform, Total & Fecal														
18. Color								3	3	3	5	3		
19. Conductivity, Specific (umr)	1350	1370	1360	1400	1370	1460	1750	1360	1300	750	1400	1400		
20. Copper (ug/l)	1	0	0	0	0	2	0	5	1	1	3	8		
21. Cyanide (mg/l)								.00	.00	.00	.00	.01		
22. Discharge (CFS)	--	2.1	1.9	1.8	1.3	2.1	2.4	2.4	2.1	2.0	2.3	1.7		
23. Dissolved Oxygen														
24. Fluoride (mg/l)	.2	.2	.2	.3	.3	.6	3.3	.2	1.2	.2	.2	.4		
(*)25. Gallium (ug/l)														
(*)26. Germanium (ug/l)														
(*)27. Hardness (Ca, Mg) (mg/l)	460	560	520	530	550	560	490	560	560	530	550	570		
(*)28. Hardness, Non-Carbonate (mg/l)	75	150	150	100	130	120	0	150	85	130	130	140		
29. Iron (ug/l)	20	50	50	20	20	620	20	10	10	20	10	10		
30. Kjeldahl Nitrogen								.22	.32	.14	.40	.45		
31. Lead (ug/l)	1	2	2	1	2	3	2	5	1	2	7	6		
32. Lithium (ug/l)	0	0	0	0	0	0	40	<10	20	10	10	10		
33. Magnesium (mg/l)	68	76	69	70	74	75	64	75	77	71	76	78		
34. Magnanese (ug/l)	0	10	0	0	0	20	0	20	0	0	10	40		
35. Mercury (ug/l)	.0	.0	.0	.0	.0	.0	.0	<.1	<.1	.0	.0	.0		
(*)36. Molybdenum (ug/l)														
(*)37. Nickel (ug/l)														
38. Nitrate (mg/l)	1.5	1.4	1.6	1.5	1.6	1.7	1.6	1.7	1.7	1.8	1.8	1.9		
39. Nitrite (mg/l)								.00	.00	.00	.01	.01		
40. Odor														
41. Oil & Grease								2	1	1	7	9		
42. Ortho-Phosphate (mg/l)	.06	.03	.03	.00	.03	.09	.03	.03	.03	.15	.03	.12		
(*)43. Ortho-Phosphorus (mg/l)	.02	.01	.01	.00	.01	.03	.01	.01	.01	.05	.01	.04		
44. Pesticides														
45. pH								8.3	8.4	8.2	7.2	8.8		
46. Potassium (mg/l)	2.0	1.6	1.9	1.9	2.3	2.0	2.4	1.1	1.4	2.0	1.7	1.6		
47. Selenium (ug/l)	1	1	0	1	1	1	2	1	1	1	1	1		
48. Silica (mg/l)	16	15	16	17	17	16	16	15	15	15	15	16		
(*)49. Silver (ug/l)														
50. Sodium (mg/l)	130	120	120	120	120	130	250	120	130	120	120	120		
(*)51. Sodium Adsorption Ratio	2.6	2.2	2.3	2.3	2.2	2.4	4.9	2.2	2.4	2.3	2.2	2.2		
(*)52. Sodium (%)	38	32	33	33	32	34	53	32	34	33	32	32		
53. Solids, Dissolved (mg/l)	865	946	915	921	919	950	1160	927	963	936	953	956		
54. Solids, Suspended														
(*)55. Strontium (ug/l)														
56. Sulfate (mg/l)	330	380	360	350	340	350	330	360	340	370	380	370		
57. Sulfide								.0	.2	.7	.2	.1		
58. Temperature (°C)	10.0	10.5	8.0	9.0	8.0	8.0	6.0	5.0	1.0	6.0	4.5	6.0		
(*)59. Tin (ug/l)														
(*)60. Titanium (ug/l)														
61. Turbidity								30	10	3	8	5		
(*)62. Vanadium (ug/l)														
63. Zinc (ug/l)	20	40	20	20	30	90	370	30	20	20	20	20		
64. Zirconium (ug/l)														
65. Calcium (mg/l)	73	98	96	95	99	99	89	99	96	97	93	98		
66. Complete Element Scan														
67. Radioactivity														
Gross Alpha (pci)														
Radium 226*														
Gross Beta														
Thorium 230**														
Uranium **														
68. Total Organic Carbon (TOC)														
If TOC > 10 mg/liter, then														
Nitrogen (Base Extraction)														
Organic Carbon, Dissolved														
Organic Carbon, Suspended														
Phenols														
Sulfur (Acid Extraction)														

(*) Not Required

* Required if Gross Alpha > 4 picocuries per liter (pci)

** Required if Gross Beta > 100 picocuries per liter (pci)

N Non-Instantaneous Discharge

NOTE: A number preceded by a less than (<) sign represents the lowest detectable limit for the analytical method used for that particular sample run. Analytical method and thus lower limit may change across sample runs even for a single element.

OCTOBER 1974 - FEBRUARY 1975

```
(*) Not Required

* Required if Gross Alpha > 4 picocuries per liter (pcl)
** Required if Gross Beta > 100 picocuries per liter (pcl)

N Non-Instantaneous Discharge
```

7

DECEMBER 1974

(*) Not Required

N Non-Instantaneous Discharge

8

TABLE II-A-5
WILLOW CREEK NEAR RIO BLANCO
U.S.G.S. No. 09306058
OCTOBER 1974 - FEBRUARY 1975

	10/4	10/9	10/17	10/23	10/31	11/6	11/20	12/6	12/17	1/3/75	1/16	2/3		
(*)1. Alkalinity (mg/l)	409	419	417	419	450	449	476	437	438	428	419	436		
(*)2. Aluminum (ug/l)								320						
3. Aromatics, Polycyclic														
4. Arsenic (ug/l)	1	2	1	1	1	0	2	1	1	0	1	4		
5. Barium (ug/l)	0	0	<100	0	<100	<100	<100	95	<100	<100	0	100		
(*)6. Beryllium (ug/l)								<2						
7. Bicarbonate (mg/l)	499	511	509	511	549	548	580	533	534	522	511	531		
(*)8. Bismuth (ug/l)								<6						
9. Boron (ug/l)	70	140	90	160	80	150	70	66	120	110	120	110		
10. Cadmium (ug/l)	0	<1	0	0	0	1	0	<20	1	0	0	1		
11. Carbonate (mg/l)								0	0	0	0	0		
(*)12. Carbon Dioxide (mg/l)								5.4	1.7	8.4	6.5	27		
13. Chloride (mg/l)	10	11	9.9	10	11	10	11	11	11	10	9.3	12		
14. Chromium (ug/l)								<6	<10	0	10	0		
(*)15. Cobalt (ug/l)								<6						
16. COD								35						
17. Coliform, Total & Fecal														
18. Color								5	3	3	5	0		
19. Conductivity, Specific (umv)	1370	1390	1380	1400	1440	1460	1470	3500	1500	1200	1350	1500		
20. Copper (ug/l)	2	2	0	0	0	2	1	3	0	0	2	4		
21. Cyanide (mg/l)								.00	.01	.00	.00	.00		
22. Discharge (CFS)	--	.56	.58	.77	--	.93	1.4	3.3	2.8	2.4	2.5	--		
23. Dissolved Oxygen														
24. Fluoride (mg/l)	.4	.4	.4	.5	.4	.2	.4	.3	.4	.4	.4	.3		
(*)25. Gallium (ug/l)								<3						
(*)26. Germanium (ug/l)								<6						
(*)27. Hardness (Ca, Mg) (mg/l)	460	490	540	490	560	570	540	560	580	550	530	550		
(*)28. Hardness, Non-Carbonate (mg/l)	51	74	130	69	110	120	68	120	140	120	110	120		
29. Iron (ug/l)	20	40	20	40	20	320	30	300	10		40	10		
30. Kjeldahl Nitrogen								.39	.20	.25	.48	1.0		
31. Lead (ug/l)	1	7	3	3	1	5	1	<6	1	1	3	2		
32. Lithium (ug/l)	0	0	0	0	0	0	0	5	10	10	10	0		
33. Magnesium (mg/l)	73	76	72	70	76	77	72	74	79	76	70	74		
34. Manganese (ug/l)	0	0	0	10	0	10	20	70	0	20	10	30		
35. Mercury (ug/l)	.0	.0	.0	.0	.0	.0	.0	<.1	<.1	.2	.0	.2		
(*)36. Molybdenum (ug/l)								3						
(*)37. Nickel (ug/l)								<4						
38. Nitrate (mg/l)								.40	.41	.40	.60	.43		
39. Nitrite (mg/l)								.00	.00	.00	.01	.00		
40. Odor														
41. Oil & Grease								4	1	7	6	5		
42. Ortho-Phosphate (mg/l)	.09	.09	.03	.03	.03	.03	.03	.09	.03	.03	.06	.15		
(*)43. Ortho-Phosphorus (mg/l)	.03	.03	.01	.01	.01	.01	.01	.03	.01	.01	.02	.05		
44. Pesticides														
45. pH								8.2	8.7	8.0	8.1	7.5		
46. Potassium (mg/l)	2.3	1.1	2.3	2.5	2.9	2.3	2.6	1.8	1.5	1.7	2.0	2.3		
47. Selenium (ug/l)	1	1	1	1	0	1	1	1	1	2	1	1		
48. Silica (mg/l)	17	18	17	18	15	8.2	17	16	16	15	16	17		
(*)49. Silver (ug/l)								0						
50. Sodium (mg/l)	130	140	120	130	130	130	140	120	120	120	120	120		
(*)51. Sodium Adsorption Ratio	2.6	2.7	2.2	2.6	2.4	2.4	2.6	2.2	2.2	2.2	2.3	2.2		
(*)52. Sodium (%)	38	38	32	37	33	33	36	32	31	32	33	32		
53. Solids, Dissolved (mg/l)	875	925	914	895	948	950	982	922	924	908	890	940		
54. Solids, Suspended														
(*)55. Strontium (ug/l)								3500						
56. Sulfate (mg/l)	330	350	340	330	340	350	350	330	330	330	320	350		
57. Sulfide								.2	.5	.1	.1	.1		
58. Temperature (°C)	11.5	14.0	8.0	11.0	6.5	9.0	8.5		3.7	.0	3.5	3.5		
(*)59. Tin (ug/l)								<6						
(*)60. Titanium (ug/l)								10						
61. Turbidity								70	30	9	40	30		
(*)62. Vanadium (ug/l)								<3.0						
63. Zinc (ug/l)	10	10	30	10	20	10	20	20	10	20	20	30		
64. Zirconium (ug/l)								<13						
65. Calcium (mg/l)	64	72	99	80	100	100	99	100	100	95	97	100		
66. Complete Element Scan														
67. Radioactivity														
Gross Alpha (pci)														
Radium 226*														
Gross Beta														
Thorium 230**														
Uranium **														
68. Total Organic Carbon (TOC)														
If TOC > 10 mg/liter, then														
Nitrogen (Base Extraction)														
Organic Carbon, Dissolved														
Organic Carbon, Suspended														
Phenols														
Sulfur (Acid Extraction)														

(*) Not Required

* Required if Gross Alpha > 4 picocuries per liter (pci)

** Required if Gross Beta > 100 picocuries per liter (pci)

N Non-Instantaneous Discharge

NOTE: A number preceded by a less than (<) sign represents the lowest detectable limit for the analytical method used for that particular sample run. Analytical method and thus lower limit may change across sample runs even for a single element.

TABLE II-A-6
 PICEANCE CREEK Ab HUNTER CREEK, Nr RIO BLANCO
 U.S.G.S. No. 09306061
 OCTOBER 1974 - FEBRUARY 1975

	10/4	10/17	10/24	10/31	11/6	11/20	12/6	12/18	1/3/ 75	1/16	2/3			
(*)1. Alkalinity (mg/l)	504	502	542	544	509	470	463	453	459	447	485			
(*)2. Aluminum (ug/l)														
3. Aromatics, Polycyclic														
4. Arsenic (ug/l)	2	2	2	1	2	4	3	2	0	1	5			
5. Barium (ug/l)	0	<100	0	<100	<100	<100	<100	<100	<100	0	<100			
(*)6. Beryllium (ug/l)														
7. Bicarbonate (mg/l)	615	612	661	663	620	573	565	552	559	545	591			
(*)8. Bismuth (ug/l)														
9. Boron (ug/l)	270	200	230	170	220	200	220	160	170	180	150			
10. Cadmium (ug/l)	0	0	0	0	5	0	1	2	0	1	1			
11. Carbonate (mg/l)							0	0	0	0	0			
(*)12. Carbon Dioxide (mg/l)							4.5	4.4	3.6	6.9	30			
13. Chloride (mg/l)	14	14	14	15	15	13	12	12	13	12	13			
14. Chromium (ug/l)							0	0	0	10	10			
(*)15. Cobalt (ug/l)														
16. COD							12							
17. Coliform, Total & Fecal														
18. Color							5	5	5	0	--			
19. Conductivity, Specific (umr)	1500	1470	1550	1560	1490	1340	1220	1400	1000	1390	1300			
20. Copper (ug/l)	4	0	2	2	2	0	2	1	2	2	5			
21. Cyanide (mg/l)							.00	.00	.00	.00	.00			
22. Discharge (CFS)	--	6.3	6.2	--	5.6	--	19	35	--	14	--			
23. Dissolved Oxygen														
24. Fluoride (mg/l)	.7	.6	.6	.7	.6	.7	.6	.7	.7	.7	.6			
(*)25. Gallium (ug/l)														
(*)26. Germanium (ug/l)														
(*)27. Hardness (Ca, Mg) (mg/l)	430	490	530	560	520	450	490	460	500	460	500			
(*)28. Hardness, Non-Carbonate (mg/l)	0	0	0	11	13	0	26	8	39	14	11			
29. Iron (ug/l)	10	30	30	10	460	10	110	10	10	10	30			
30. Kjeldahl Nitrogen							1.4	.58	.93	.52	.46			
31. Lead (ug/l)	0	.3	2	0	5	2	1	2	3	6	2			
32. Lithium (ug/l)	0	0	0	0	0	0	10	10	10	10	10			
33. Magnesium (mg/l)	69	69	78	82	75	60	66	61	68	64	67			
34. Magnanese (ug/l)	0	150	170	140	150	60	40	30	30	20	40			
35. Mercury (ug/l)	.0	.0	.0	.0	.0	.0	<.1	<.1	.0	.0	.1			
(*)36. Molybdenum (ug/l)														
(*)37. Nickel (ug/l)														
38. Nitrate (mg/l)	.31	.29	.27	.19	.18	.55	.64	.79	.73	.77	.68			
39. Nitrite (mg/l)							.01	.00	.00	.01	.01			
40. Odor														
41. Oil & Grease							8	3	9	7	8			
42. Ortho-Phosphate (mg/l)	.18	.09	.12	.09	.03	.03	.06	.03	.09	.06	.25			
(*)43. Ortho-Phosphorus (mg/l)	.06	.03	.04	.03	.01	.01	.02	.01	.03	.02	.08			
44. Pesticides														
45. pH							8.3	8.3	8.4	8.1	7.5			
46. Potassium (mg/l)	1.2	3.8	4.3	3.5	4.0	3.0	2.6	2.5	2.8	2.6	2.7			
47. Selenium (ug/l)	1	1	1	0	1	1	1	1	2	1	1			
48. Silica (mg/l)	20	19	19	19	17	17	16	19	16	17	17			
(*)49. Silver (ug/l)														
50. Sodium (mg/l)	180	180	170	180	170	150	140	140	140	140	140			
(*)51. Sodium Adsorption Ratio	3.8	3.5	3.2	3.3	3.2	3.1	2.8	2.8	2.7	2.8	2.7			
(*)52. Sodium (%)	48	44	41	41	41	42	38	40	38	40	38			
53. Solids, Dissolved (mg/l)	949	992	1030	1050	1000	870	887	886	907	878	944			
54. Solids, Suspended														
(*)55. Strontium (ug/l)														
56. Sulfate (mg/l)	300	320	330	330	330	260	280	290	300	290	320			
57. Sulfide							.2	.5	.0	.0	.2			
58. Temperature (°C)	14.0	14.0	10.0	8.0	10.0	6.5	5.0	2.5	.0	1.0	.0			
(*)59. Tin (ug/l)														
(*)60. Titanium (ug/l)														
61. Turbidity							80	40	20	30	10			
(*)62. Vanadium (ug/l)														
63. Zinc (ug/l)	10	10	20	0	10	10	30	0	10	30	30			
64. Zirconium (ug/l)														
65. Calcium (mg/l)	89	82	83	87	85	81	87	84	87	79	88			
66. Complete Element Scan														
67. Radioactivity														
Gross Alpha (pci)														
Radium 226*														
Gross Beta														
Thorium 230**														
Uranium **														
68. Total Organic Carbon (TOC)														
If TOC > 10 mg/liter, then														
Nitrogen (Base Extraction)														
Organic Carbon, Dissolved														
Organic Carbon, Suspended														
Phenols														
Sulfur (Acid Extraction)														

(*) Not Required

* Required if Gross Alpha > 4 picocuries per liter (pci)
 ** Required if Gross Beta > 100 picocuries per liter (pci)

N Non-Instantaneous Discharge

NOTE: A number preceded by a less than (<) sign represents the lowest detectable limit for the analytical method used for that particular sample run. Analytical method and thus lower limit may change across sample runs even for a single element.

II B CORE DRILLING AND ASSOCIATED GROUND WATER

The raw data generated by the exploratory well drilling program on Tract C-b is voluminous, comprising thousands of pages in Quarterly Report #2 alone. Detailed analysis of most of these data is incomplete but where interpretations have been made and conclusions drawn, they are included in this Summary Report. Table II B-1 is a well summary table listing the wells completed to date and the various types of information presented in either Quarterly Report #1 or Quarterly Report #2.

Good

Well logs and coring information were used to prepare Figure II B-1, a preliminary isopach showing the depth of overburden above the anticipated mine roof as it varies across the tract. Figure II B-2 presents an East-West stratigraphic cross-section, illustrating the various zones and markers from the Evacuation Creek Member to the Douglas Creek Member.

As additional geologic data are obtained, further geologic maps and cross-sections will be prepared.

II B-1 Well Survey Plats

No additional survey plats were presented this quarter.

II B-2 Completion Data

Well completion diagrams are presented in Quarterly Report #2 for wells AT-1, Cb-2, SG-1, SG-1a, SG-8, SG-17, SG-20 and SG-21.

Have SG. 4+10 been drilled?

II B-3 Drilling Water Production

During the drilling of wells and core holes on and adjacent to Tract C-b, records were kept of drilling water production data. The records included produced water temperature and specific conductivity as well as produced and injected water volumes. Such readings were taken at approximately 30 foot intervals. These data are included in raw form in the Quarterly Reports.

Production data for wells AT-1, SG-1, SG-1a, SG-17, SG-20 and SG-21 were accumulated during the second quarter. The conductivity, temperature and discharged water volume have been graphed for each well vs. depth. The graphs are included in this section as Figures II B-3 through II B-8.

Two preliminary drilling water production cross-sections of the tract (one East-West, the other North-South) were also prepared and are presented without interpretation in Figures II B-9 and II B-10.

Table II B-1
Well Summary Table

1. Well Designation	AT-1	AT-1a	AT-1a1	AT-1b	AT-1c	AT-1d	SG-1	SG-1a	SG-6	SG-8	SG-9	SG-10	SG-10a	SG-11
2. Well Type	AT	AT CH	AT	AT	AT	AT	CH	GHT	AT CH	CH	CH	AT CH	GHT	AT CH
3. Drilling Completion Date	1/23 75	7/1 74	7/10 74	7/20 74	8/18 74	7/28 74	12/6 74	2/7 75	8/22 74	11/27 74	10/23 74	6/29 74	7/10 74	9/8 74
4. Total Depth (Feet)	1338	1621	1341	1638	1640	1640	2525	1180	2220	2608	2750	2211	1333	2826
5. Water Data														
a. Drilling Water Production	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q			C1Q	C1Q	C1Q	C1Q	C1Q	C1Q
b. Drilling Water Samples (Number)	1	4	NA	NA	4	NA	7		5		5	4	NA	25
c. Water Quality Analyses	C1Q	C1Q			C1Q		C2Q		C1Q		C1Q	C1Q		C1Q
6. Aquifer Data														
a. Drill Stem Tests		C1Q			C1Q							C1Q		
b. Jetting Tests	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C2Q		C1Q	C1Q	C1Q	C1Q	C1Q	C1Q
7. Geophysical Logs, Schlumberger					Inc.				Inc.					
a. Borehole, Compensated Sonic	C1Q			C1Q		C1Q	C2Q			C2Q	C2Q			C1Q
b. Laterolog	C1Q			C1Q		C1Q	C2Q			C2Q	C2Q			C1Q
c. Formation Density	C1Q			C1Q		C1Q	C2Q	C2Q		C2Q	C2Q			
d. Nuclear Formation Density				C1Q		C1Q								
e. Temperature	C1Q	C1Q		C1Q		C1Q	C2Q			C2Q	C2Q	C1Q		C1Q
f. Cement Bond Log						Inc.								Inc.
8. Geophysical Logs, Birdwell														
a. Velocity, 3-dimensional		C1Q										C1Q		
b. Electric		C1Q										C1Q		
c. Density		C1Q										C1Q		
d. Nuclear		C1Q										C1Q		
e. Caliper		C1Q										C1Q		
f. Temperature		C1Q										C1Q		
9. Geophysical Logs, Other														
a. Welex, Micro-seismogram		Inc.										Inc.		
b. McCullough, Temperature				Inc.										
10. Field Lithologic Log	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C2Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q
11. Cored Interval (Feet From Surface)														
a. Top	NA	1270	NA	NA	NA	NA	550		1195	580	1200	1200	NA	750
b. Bottom	NA	1519	NA	NA	NA	NA	2525		2220	2608	2750	2211	NA	2810
12. Assay Data														
a. Fischer Assay	NA	C1Q	NA	NA	NA	NA					C2Q	C1Q	NA	C1Q
b. Soluble Sodium	NA	C1Q	NA	NA	NA	NA					C2Q	C1Q	NA	
c. Alumina	NA	C1Q	NA	NA	NA	NA					C2Q	C1Q	NA	
13. Trace Element Analysis			C2Q							C2Q	C2Q	C2Q		
14. Rock Mechanics Data		C1Q												
15. Gas Data														
a. Drilling Log	NA	NA	NA	NA		NA	C1Q		C1Q	C1Q	C1Q		NA	C1Q
b. Bomb Samples (Number Taken)	NA	NA	NA	NA	2	NA	8		4	11	8		NA	6
c. Bomb Analyses	NA	NA	NA	NA	C2Q	NA	C1Q2Q		C1Q	C1Q2Q	C1Q			C1Q
16. Completion Data	C2Q	C1Q	C1Q	C1Q	C1Q	C1Q	C2Q	C2Q	C1Q	C2Q	C1Q	C1Q	C1Q	C1Q
17. Survey Plat	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q		C1Q	C1Q	C1Q	C1Q		C1Q

KEY: NA = Not Applicable
Inc. = Incomplete
C1Q = Complete, First Quarterly Report
C2Q = Complete, Second Quarterly Report

AT = Aquifer Test Well
AW = Alluvial Well
CH = Standard Core Hole
GHT = Ground Water/Hydrologic Test Well
AB = Abandoned

12,13
14,15
16

Table II B-1
Well Summary Table (Continued)

were they drilled?

1. Well Designation	SG-17	SG-18	SG-18a	SG-19	SG-20	SG-21	Cb-1	Cb-2	Cb-2b	Cb-3	Cb-4			
2. Well Type	CH	AB	GHT	CH GHT	GHT	GHT	GHT	GHT	AB	GHT	GHT			
3. Drilling Completion Date	1/13 75	10/13 74	10/18 74	9/28 74	12/13 74	1/8 75	OLD	OLD	9/20 74	OLD	OLD			
4. Total Depth (Feet)	2460	1426	1330	980	981	1036	2103	1469	1220		1470			
5. Water Data														
a. Drilling Water Production		C1Q	C1Q	C1Q			NA	NA	C1Q	NA	NA			
b. Drilling Water Samples (Number)	31	3	1	4	5	5								
c. Water Quality Analyses	C2Q	C1Q	C1Q	C1Q	C2Q	C2Q								
6. Aquifer Data														
a. Drill Stem Tests	C2Q				C2Q	C2Q	NA	NA		NA	NA			
b. Jetting Tests		C1Q	C1Q	C1Q	C2Q	C2Q	NA	NA	C1Q	NA	NA			
7. Geophysical Logs, Schlumberger														
a. Borehole, Compensated Sonic	C2Q	C1Q		C1Q	C2Q	C2Q								
b. Laterolog	C2Q	C1Q		C1Q		C2Q								
c. Formation Density	C2Q	C1Q		C1Q	C2Q	C2Q								
d. Nuclear Formation Density														
e. Temperature	C2Q	C1Q		C1Q	C2Q	C2Q								
f. Cement Bond Log								Inc.			Inc.			
8. Geophysical Logs, Birdwell														
a. Velocity, 3-dimensional														
b. Electric														
c. Density														
d. Nuclear														
e. Caliper														
f. Temperature							C1Q	C1Q		C1Q	C1Q			
9. Geophysical Logs, Other														
a. Welox, Micro-seismogram														
b. McCullough, Temperature														
10. Field Lithologic Log	C2Q	C1Q	C1Q	C1Q	C2Q	C2Q	NA	NA	C1Q	NA	NA			
11. Cored Interval (Feet From Surface)														
a. Top		1380	NA	930			NA	NA	NA	NA	NA			
b. Bottom		1426	NA	980			NA	NA	NA	NA	NA			
12. Assay Data														
a. Fischer Assay		C1Q	NA	C1Q			NA	NA	NA	NA	NA			
b. Soluble Sodium							NA	NA	NA	NA	NA			
c. Alumina							NA	NA	NA	NA	NA			
13. Trace Element Analysis														
14. Rock Mechanics Data							NA	NA	NA	NA	NA			
15. Gas Data														
a. Drilling Log	C2Q	C1Q	C1Q	C1Q	C2Q	-	NA	NA	C1Q	NA	NA			
b. Bomb Samples (Number Taken)	31	1	1	4	5	4	NA	NA	1	NA	NA			
c. Bomb Analyses	C1Q2Q	C1Q	C1Q	C1Q	C2Q	C2Q	NA	NA	C1Q	NA	NA			
16. Completion Data	C2Q	C1Q	C1Q	C1Q	C2Q	C2Q	C1Q	C2Q	C1Q	C1Q	C1Q			
17. Survey Plat	C1Q	C1Q		C1Q	C1Q	C1Q	C1Q	C1Q		C1Q	C1Q			

KEY: NA = Not Applicable
Inc. = Incomplete
C1Q = Complete, First Quarterly Report
C2Q = Complete, Second Quarterly Report

AT = Aquifer Test Well
AW = Alluvial Well
CH = Standard Core Hole
GHT = Ground Water/Hydrologic Test Well
AB = Abandoned

Table II B-1
Well Summary Table (Continued)

1. Well Designation	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	
2. Well Type	AW	AW	AW	AW	AW	AW	AW	AW	AW	AW	AW	AW	AW	
3. Drilling Completion Date	10/2 74	10/4 74	10/7 74	10/8 74	10/3 74	10/10 74	9/28 74	10/1 74	9/23 74	9/23 74	9/24 74	9/24 74	10/8 74	
4. Total Depth	109	82	112	64	86	60	51	70	57	67	66	81	14	
5. Water Data														
a. Drilling Water Production														
b. Drilling Water Samples (Number)														
c. Water Quality Analyses	C1Q	C1Q	C1Q	NA	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	NA	
6. Aquifer Data														
a. Drill Stem Tests														
b. Jetting Tests														
7. Geophysical Logs, Schlumberger														
a. Borehole, Compensated Sonic														
b. Laterolog														
c. Formation Density														
d. Nuclear Formation Density														
e. Temperature														
f. Cement Bond Log														
8. Geophysical Logs, Birdwell														
a. Velocity, 3-dimensional														
b. Electric														
c. Density														
d. Nuclear														
e. Caliper														
f. Temperature														
9. Geophysical Logs, Other														
a. Welex, Micro-seismogram														
b. McCullough, Temperature														
10. Field Lithologic Log	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C2Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	
11. Cored Interval (Feet From Surface)														
a. Top														
b. Bottom														
12. Assay Data														
a. Fischer Assay														
b. Soluble Sodium														
c. Alumina														
13. Trace Element Analysis														
14. Rock Mechanics Data														
15. Gas Data														
a. Drilling Log														
b. Bomb Samples (Number Taken)														
c. Bomb Analyses														
16. Completion Data	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	
17. Survey Plat	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	C1Q	

KEY: NA = Not Applicable
 Inc. = Incomplete
 C1Q = Complete, First Quarterly Report
 C2Q = Complete, Second Quarterly Report

AT = Aquifer Test Well
 AW = Alluvial Well
 CH = Standard Core Hole
 GHT = Ground Water/Hydrologic Test Well
 AB = Abandoned

FIGURE II B-1

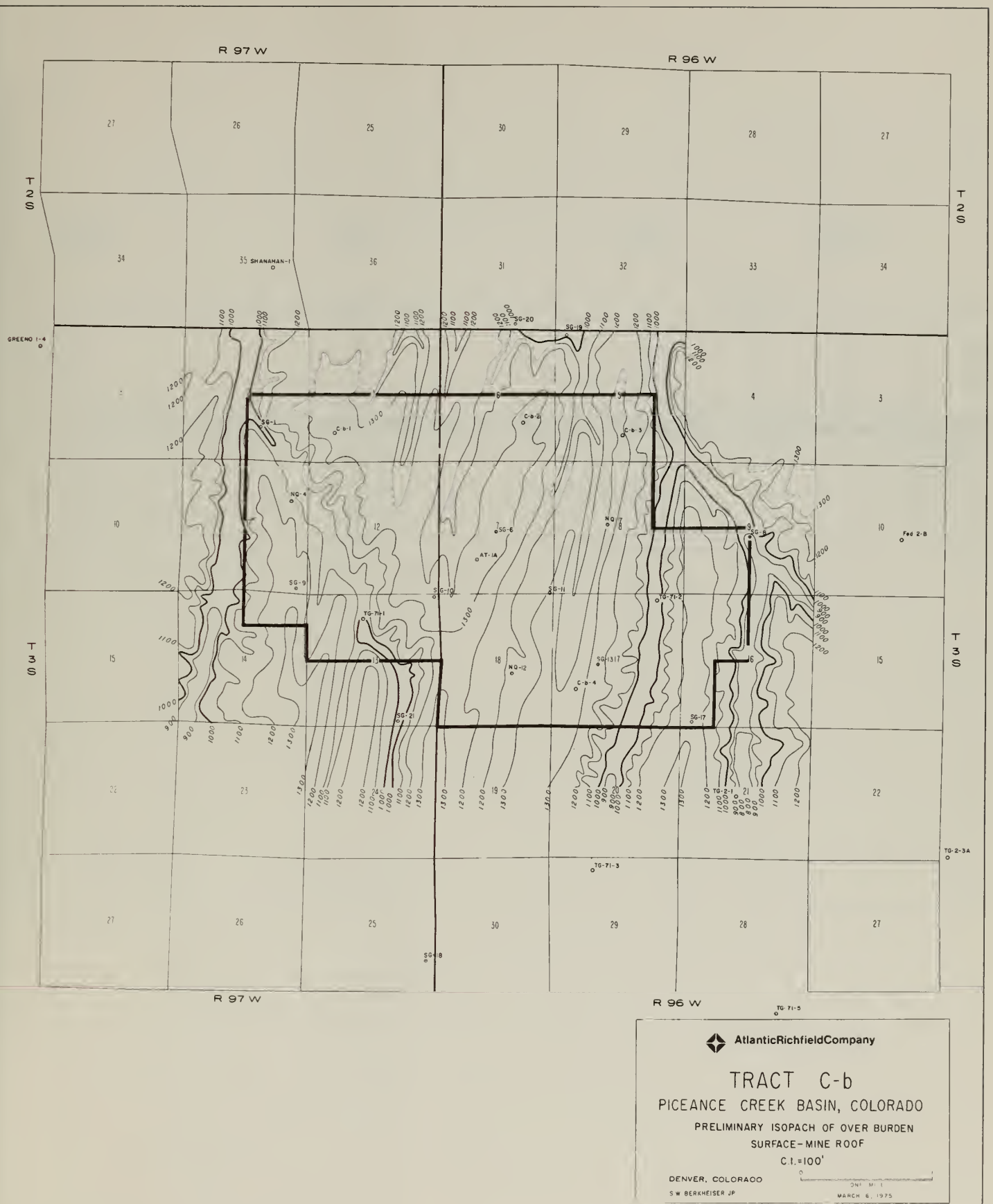


FIGURE 11 B-2

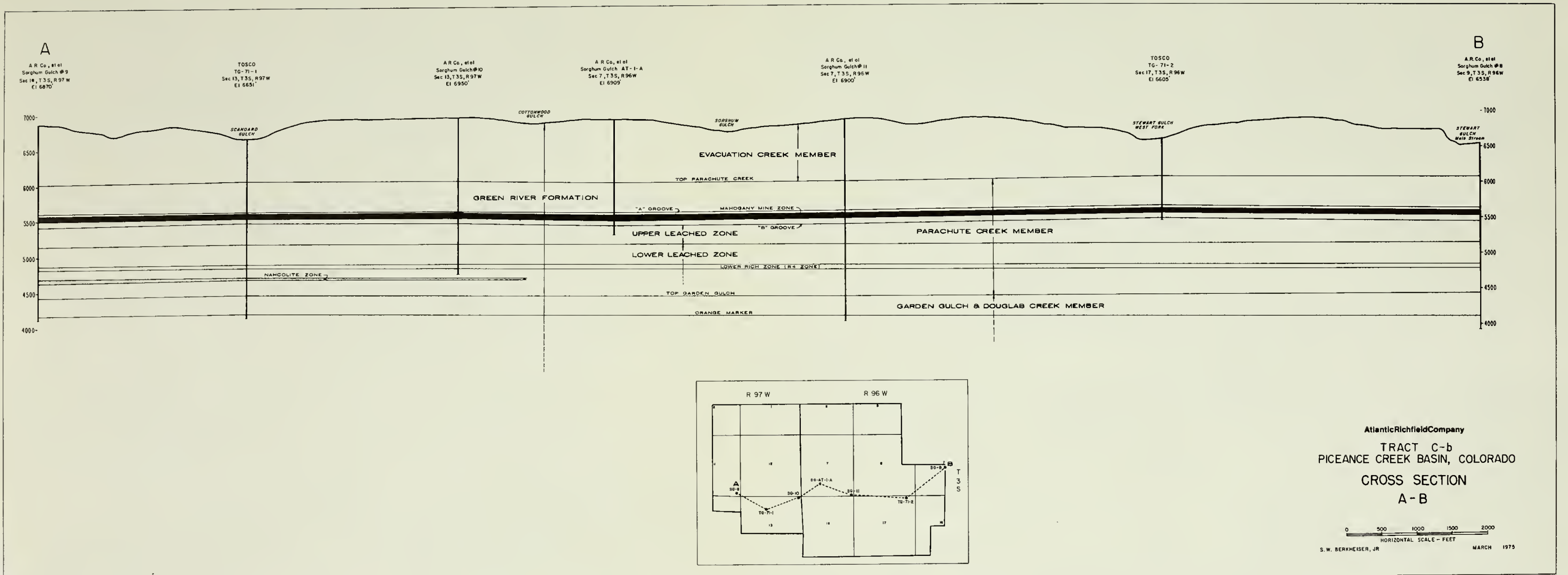


FIGURE 11 B-3

DEPTH vs TEMPERATURE, CONDUCTIVITY & WATER PRODUCTION AT-1

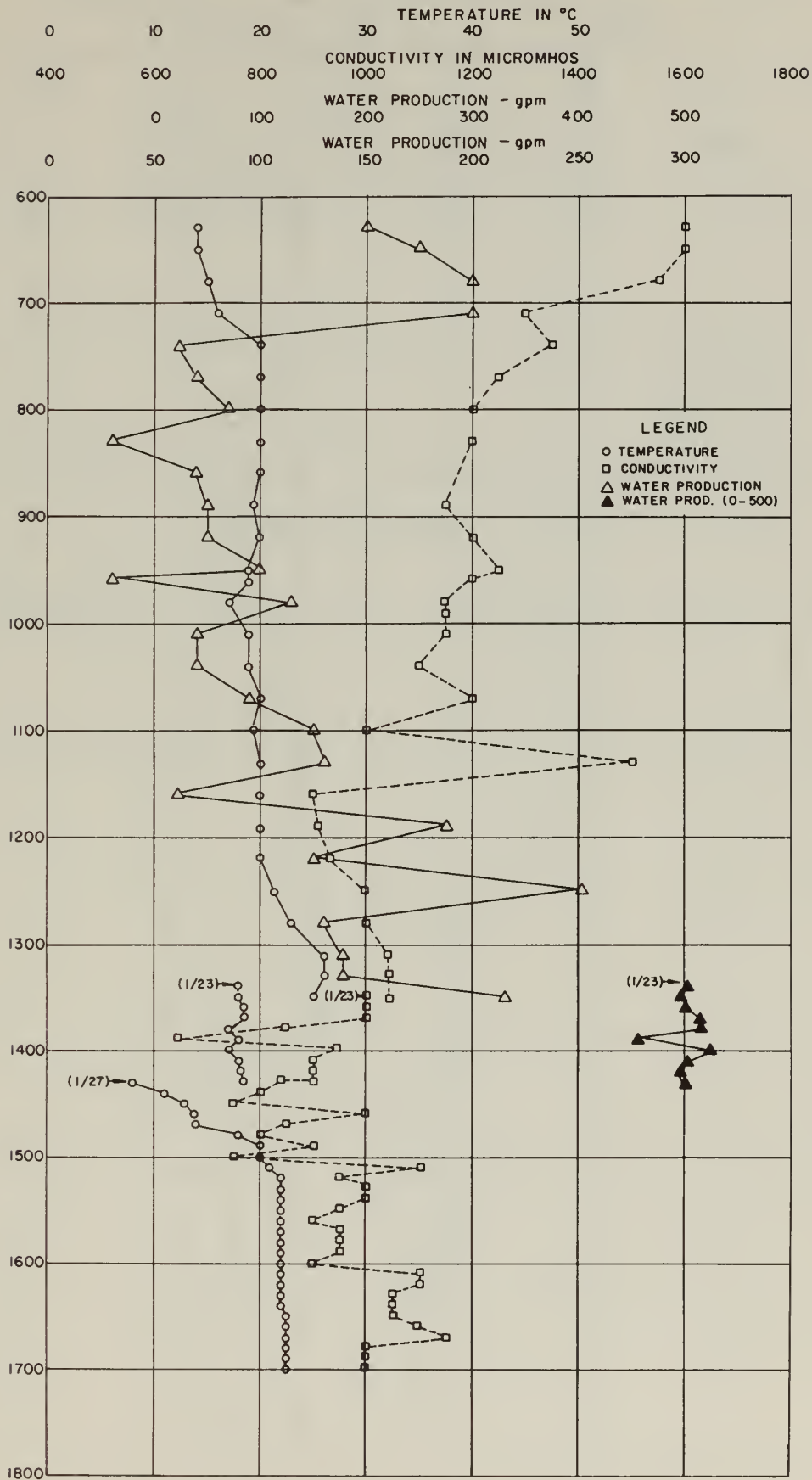


FIGURE II B-4

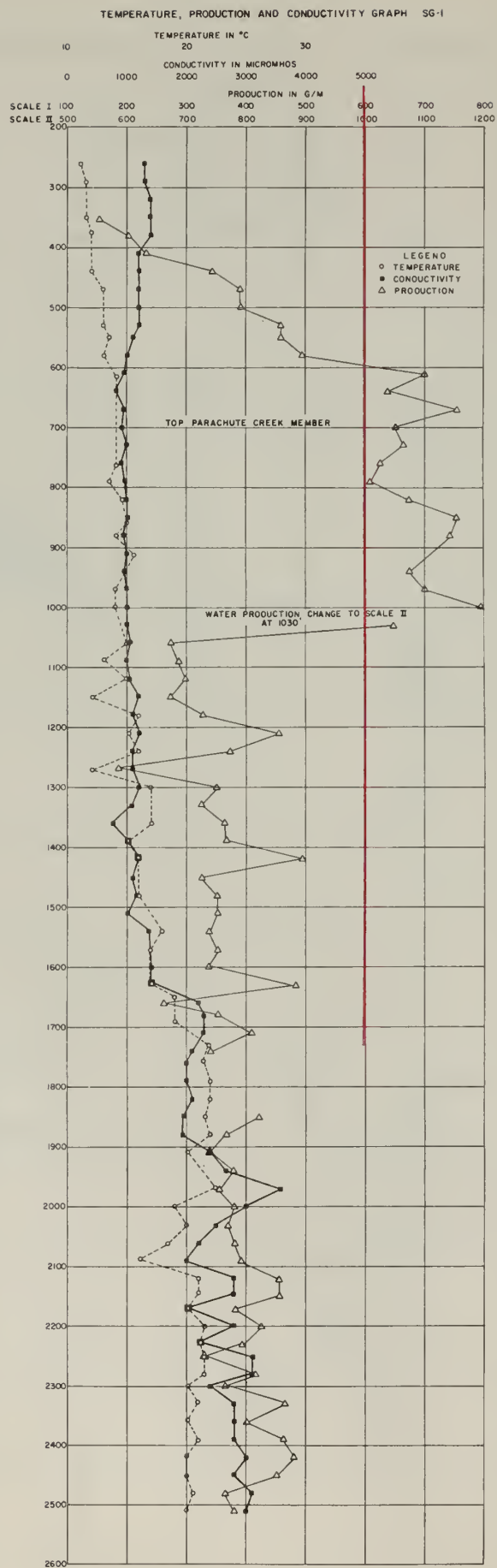


FIGURE II B-5

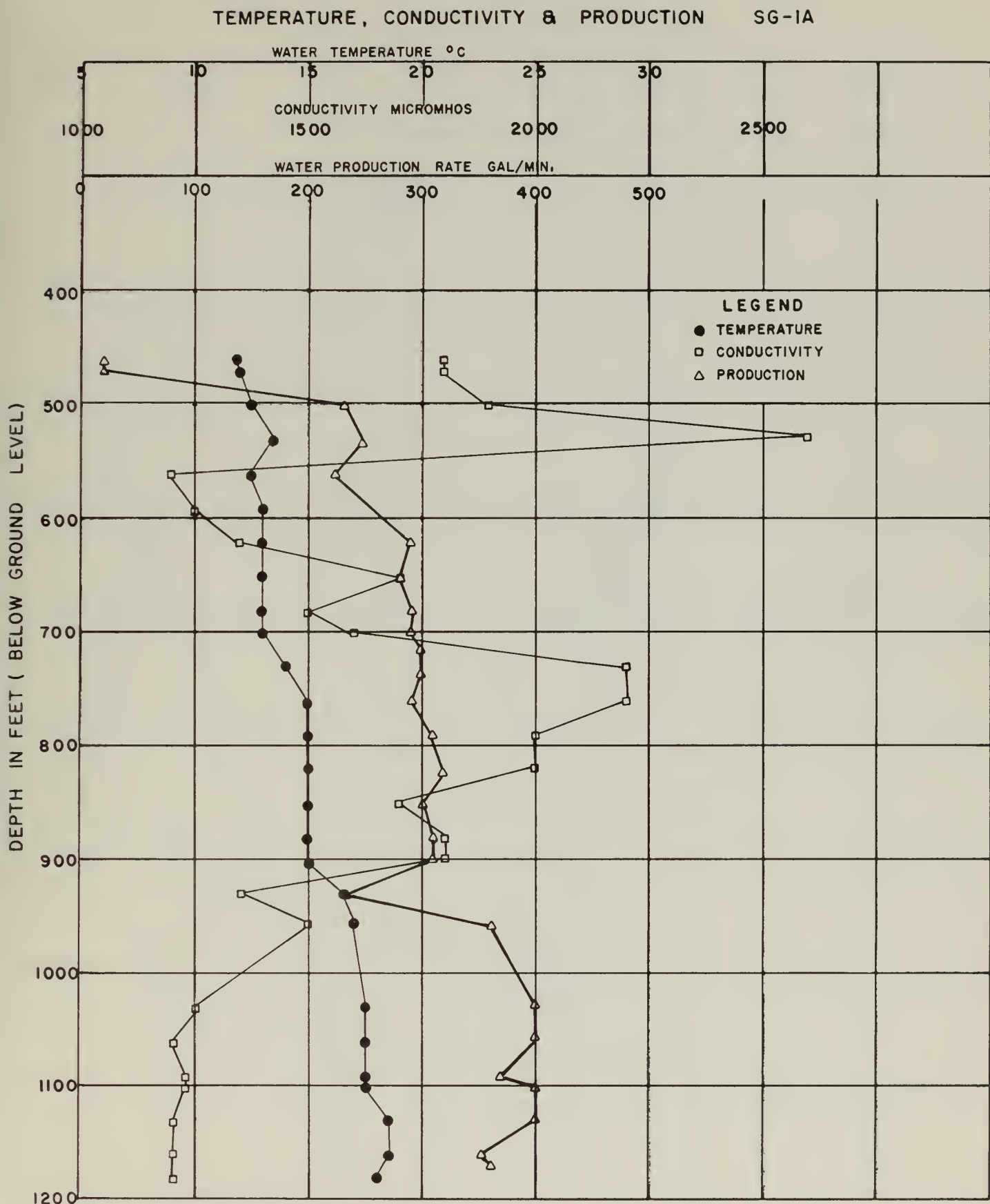


FIGURE II B-6

TEMPERATURE, PRODUCTION AND CONDUCTIVITY GRAPH SG-17

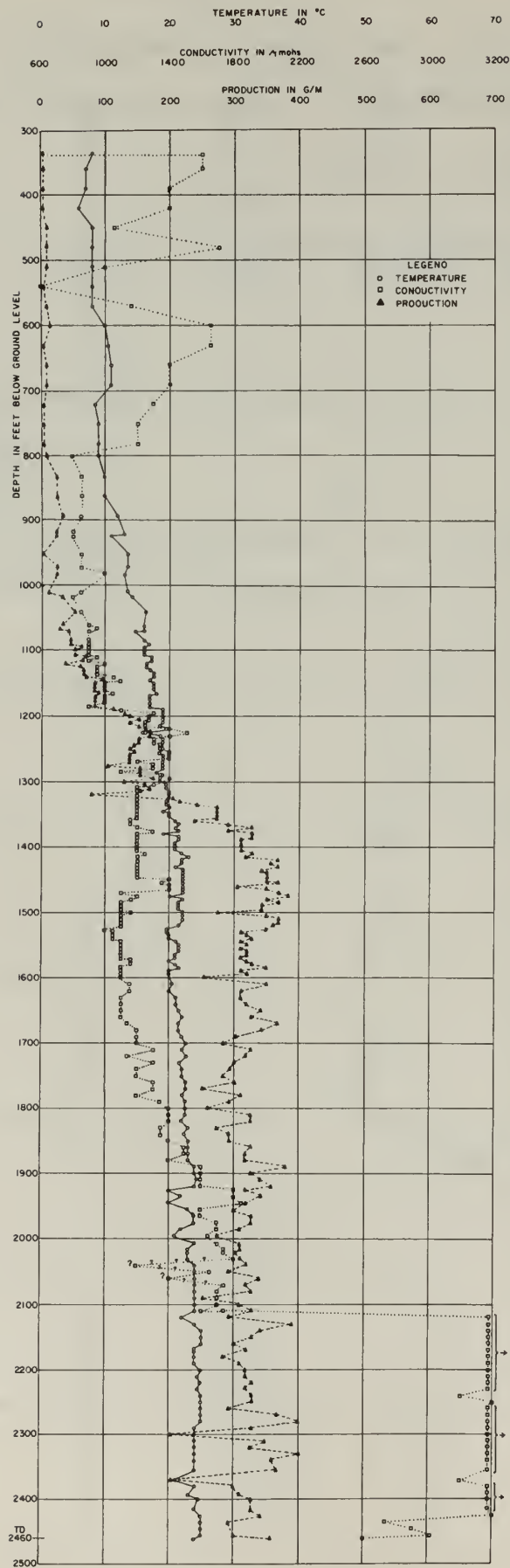


FIGURE II B-7

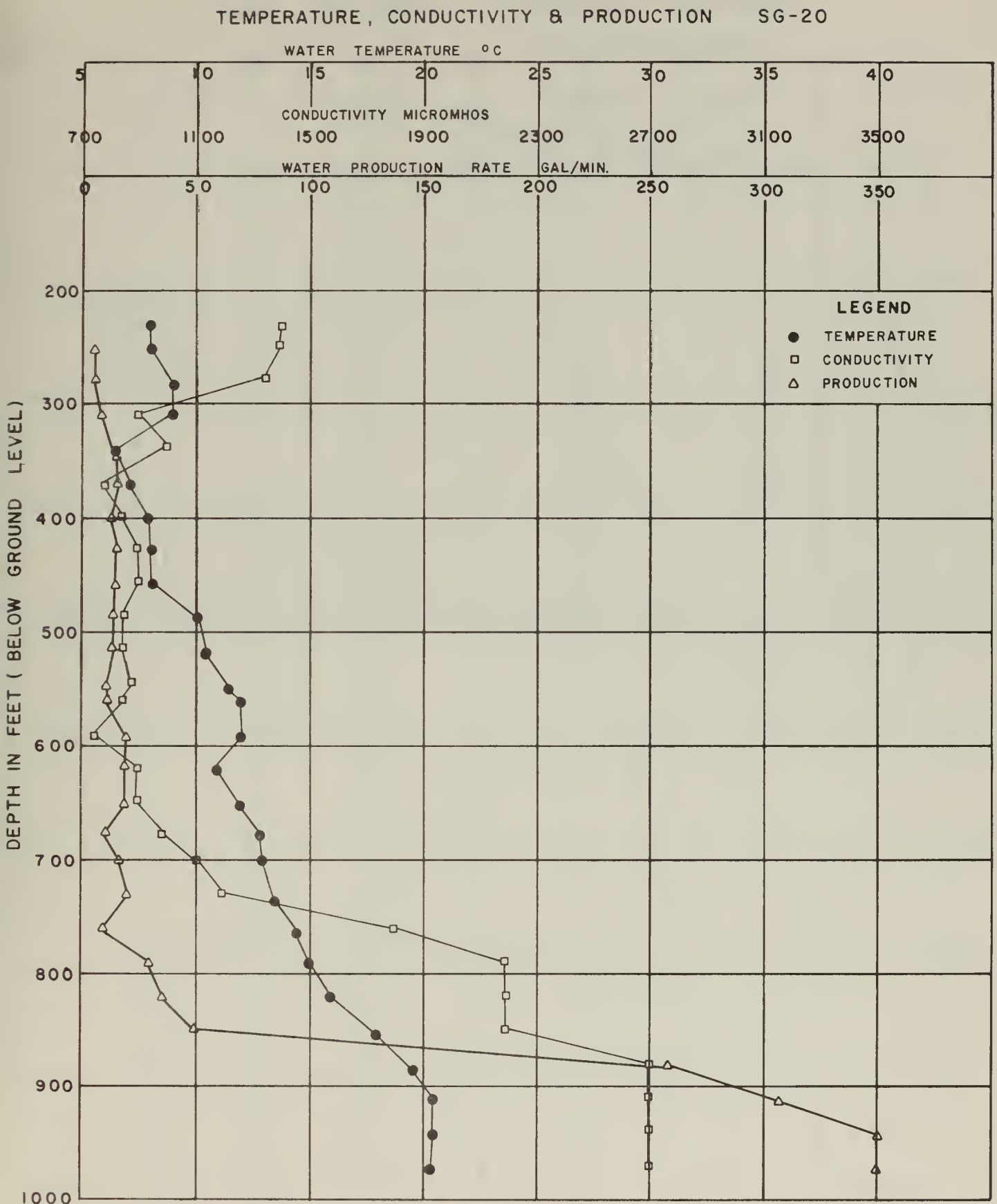


FIGURE II B-8

TEMPERATURE, CONDUCTIVITY & PRODUCTION SG-21

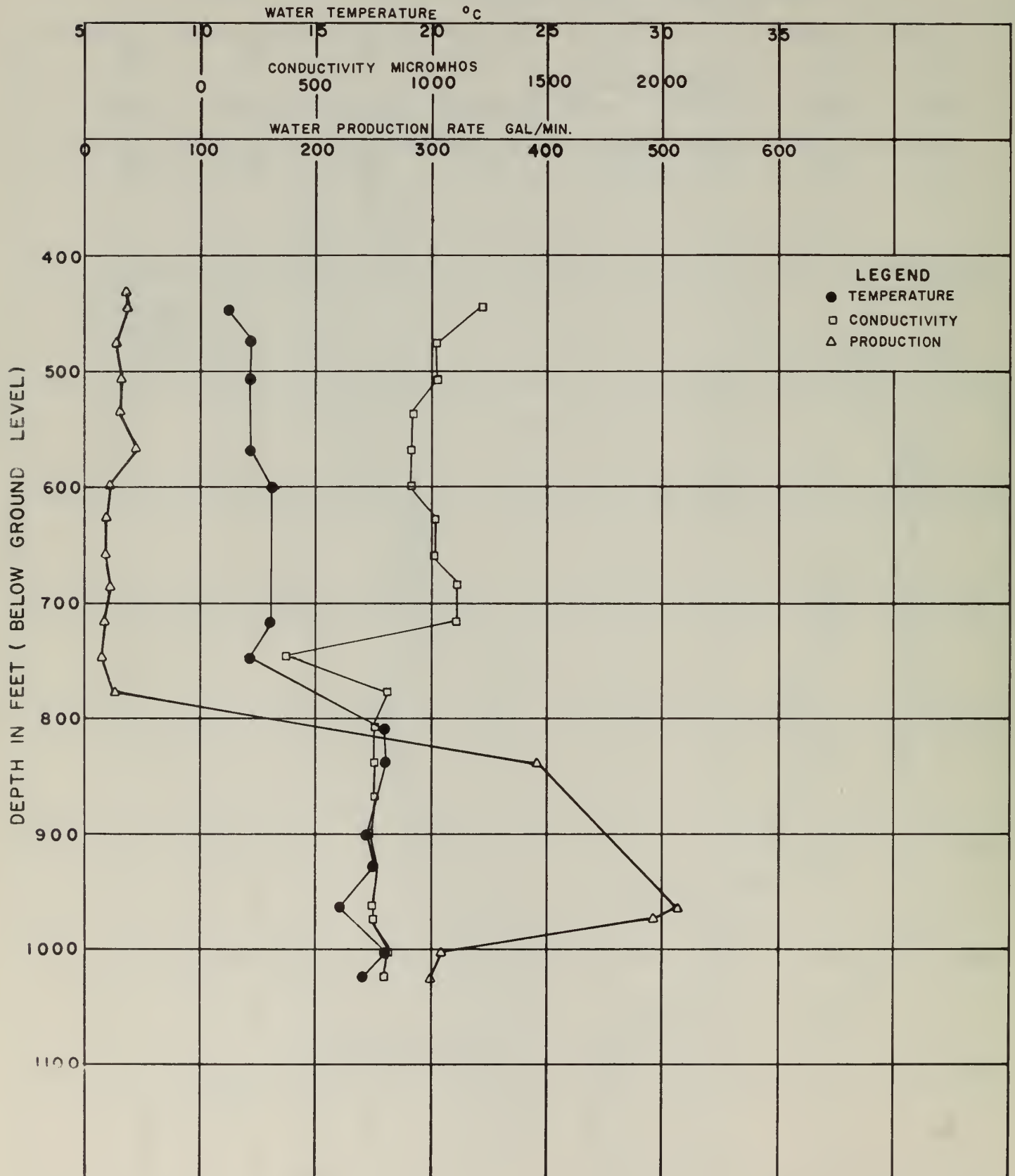
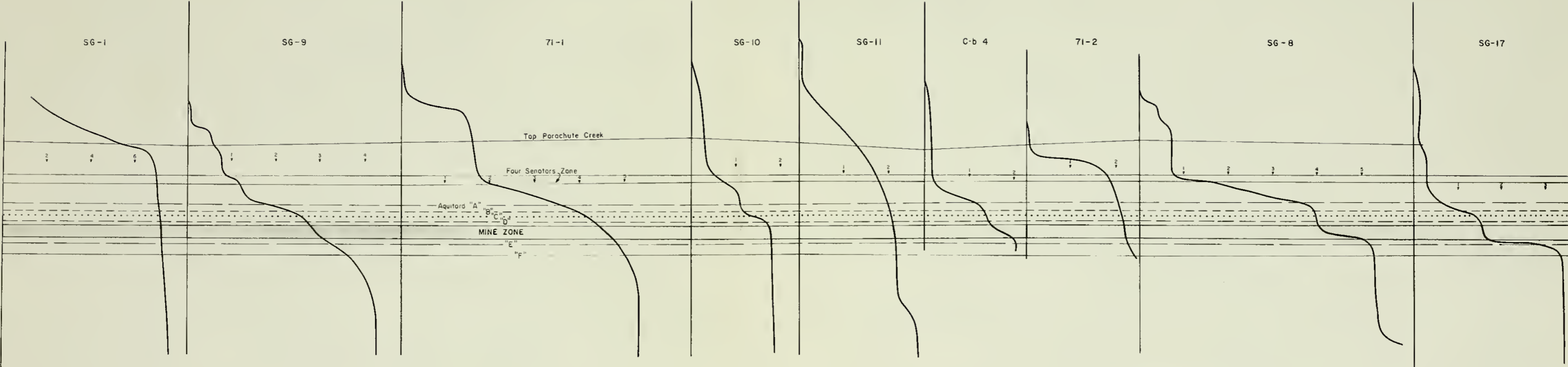


FIGURE II B-9



NOTE FIGURE DOES NOT DEPICT
GEOGRAPHIC DISTANCE
BETWEEN HOLES

EAST-WEST STRATIGRAPHIC SECTION
C-b TRACT
WATER PRODUCTION CURVES

VERTICAL AXIS DEPTH BELOW SURFACE
HORIZONTAL AXIS 100 GALLONS PER MINUTE

D B TAIT JANUARY 11, 1975

FIGURE II B-8

TEMPERATURE, CONDUCTIVITY & PRODUCTION SG-21

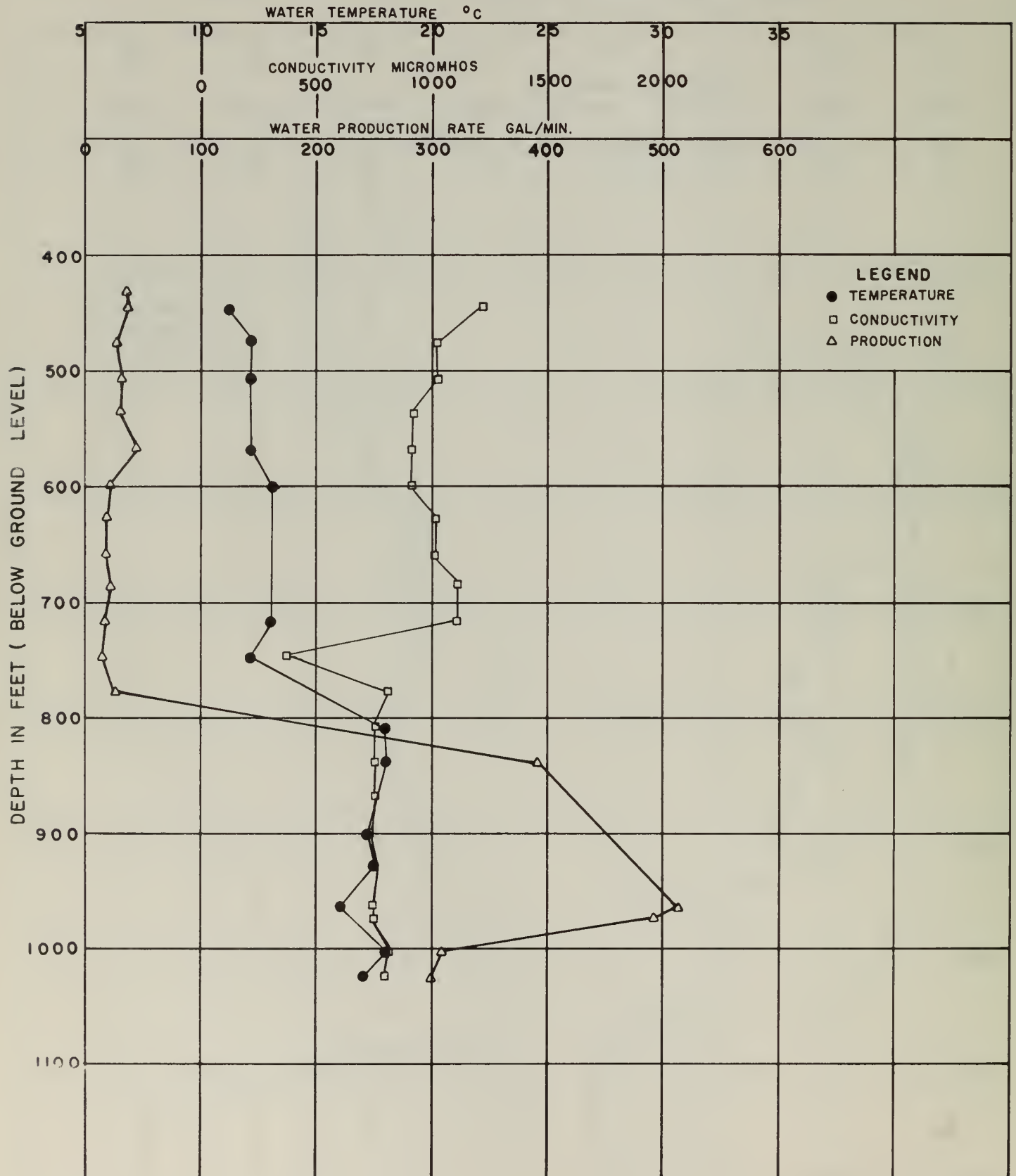
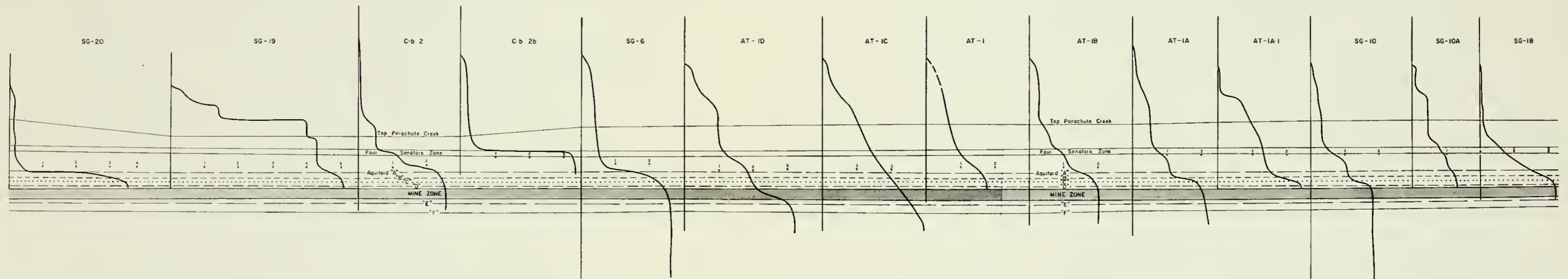


FIGURE 11 B-10



NOTE: FIGURE DOES NOT DEPICT
GEOGRAPHIC DISTANCE BETWEEN HOLES

NORTH-SOUTH STRATIGRAPHIC SECTION
C-b TRACT
WATER PRODUCTION CURVES
VERTICAL AXIS: DEPTH BELOW SURFACE
HORIZONTAL AXIS: 100 GALLONS PER MINUTE
D B TAIT JANUARY 11, 1975

II B-4 Water Quality - Drilling

During the drilling of a well or core hole, samples of the produced water are collected for analysis. Jetting test samples are collected for every well. It should be noted that the sample depth indicates the depth at which the drilling bit was located when the sample was taken. Since the samples are taken from the drilling water flow line, the data reflect a composite of conditions from surface to drilling bit depth.

Samples were also taken during drill stem tests which were conducted in some of the wells. In a drill stem test, a packer is used to isolate a portion of the well bore at some interval above the bottom of the hole and water is then jetted from the isolated interval. The sample collected should represent ground-water conditions in the discrete subsurface interval between the packer and the bottom of the well.

Tables II B-2 and II B-3 list the water samples collected from jetting tests and drill stem tests for which data are presented in Quarterly Report #2.

II B-5 Water Quality - Baseline

Several wells or core holes have been drilled, completed and sampled as part of the ground water baseline monitoring network. The analyses of some of those initial baseline samples are included in Section II B-5 of Quarterly Report #2. Some data appeared in Quarterly Report #1 as upper zone samples during drilling, alluvial well samples, and monitoring samples. In the future, most ground water analytical data will appear in the Baseline Water Quality Section of the quarterly reports. Drilling activity, and hence drilling water data, will be greatly reduced in 1975.

On a semi-annual basis ground water samples will be collected from all appropriate well bores and analyzed for baseline documentation. The constituent list may change from time to time as criteria are reviewed and modified.

The Project is now five months into the first year of baseline documentation. Therefore, in April (extending into May) the next major ground water sampling run will commence. Data from that sampling run may or may not be available for Quarterly Report #3, depending on analytical lag time. Until those samples are collected and analyzed, detailed ground water quality interpretation and/or correlation, based upon the baseline ground water monitoring network, would be inappropriate.

II B-6 Water Quality - Aquifer Pump Tests

Table II B-4 lists results of the analyses of three samples from the aquifer pump test well, AT-1. The first sample was collected

TABLE II B-2
WATER QUALITY SAMPLES
JETTING TESTS AND DRILL STEM TESTS

Well	Test	Sample Depth Feet
SG-1	JT	613
SG-1	JT	706
SG-1	JT	990
SG-1	JT	1105
SG-1	JT	2179
SG-1	JT	2525
SG-1	DST	lower zone (below 1930)
SG-20	JT	515
SG-20	JT	850
SG-20	JT	987
SG-20	DST	945
SG-21	JT	676
SG-21	JT	980
SG-21	JT	1035
SG-21	DST	1000-1035
SG-21	DST	950-1009
SG-8	JT	600
SG-8	JT	971
SG-8	JT	1013
SG-8	JT	2117
SG-8	JT	2608
SG-8	DST	lower zone (below 1910)
SG-8	DST	upper zone (950 to surface)

JT = Jetting Tests
DST = Drill Stem Tests

TABLE II B-3

Water Quality Samples Collected During The Drilling
of SG-17

<u>Sample No.</u>	<u>Drill Stem Test No.</u>	<u>Sample Interval (Feet)</u>	<u>Sample Type</u>
1	DST 1	788-808	Environmental (1)
2		859	Minimum (2)
3	DST 3	822-869	Minimum
4	DST 4	866-919	Minimum
5	DST 5	919-970	Minimum
6	DST 6	970-1017	Minimum
7	DST 7	1015-1062	Environmental
8	DST 8	1066-1117	Environmental
9	DST 9	1115-1166	Minimum
10		1180	Minimum
11	DST 10	1164-1212	Minimum
12	DST 11	1200-1224	Minimum
13	DST 13	1224-1250	Minimum
14	DST 14	1250-1271	Minimum
15	DST 15	1280-1309	Minimum
16	DST 17	1329-1374	Minimum
17	DST 18	1374-1419	Minimum
18	DST 19	1423-1470	Minimum
19	DST 21	1473-1522	Minimum
20	DST 23	1514-1752	Minimum
21	DST 24	1561-1622	Minimum
22	DST 25	1618-1670	Minimum
23		1622	Minimum
24	DST 26	1668-1720	Minimum
25	DST 27	1711-1770	Minimum
26	DST 28	1768-1820	Minimum
27	DST 29	1818-1870	Minimum
28	DST 30	1869-1920	Minimum
29	DST 31	1918-1970	Minimum
30	DST 34	2120-2170	Environmental
31		2608	Minimum

(1) Complete chemical analysis per environmental baseline samples.

(2) Minimum analysis done.

WATER QUALITY ANALYSIS
AQUIFER PUMP TESTS

Well Number: AT-1

Date	9/15/74	10/22/74	12/23/74		
Element Measured		(15 hours)			
1. Aluminum (ug/l)		.04			
2. Ammonia (mg/l)		0.8			
3. Arsenic (ug/l)		.02			
4. Barium (ug/l)		.01			
5. Beryllium (ug/l)					
6. Bicarbonate (mg/l)	435	420	570		
7. Bismuth (ug/l)		<.005			
8. Boron (ug/l)		0.7	1.5		
9. Cadmium (ug/l)		<.005			
10. Calcium (mg/l)	40	61	16		
11. Carbonate (mg/l)		24	<.1		
12. Cerium (mg/l)		<.005			
13. Chloride (mg/l)	3	7	7		
14. Chrome, Hexavalent (mg/l)		<.01			
15. Cobalt (ug/l)		.001			
16. Conductivity, Specific (u ν)	1050	990			
17. Copper (ug/l)		.02			
18. Fluoride (mg/l)	2.7	4.8	18		
19. Gallium (ug/l)		<.005			
20. Hardness, Total (mg/l)		180			
21. Hydroxide (mg/l)		<.1			
22. Iron (ug/l)		.4			
23. Lead (ug/l)		.01			
24. Lithium (ug/l)		.08			
25. Magnesium (mg/l)	34	7.9	9.5		
26. Manganese (ug/l)		.01			
27. Mercury (ug/l)		.0085			
28. Molybdenum (ug/l)		.005			
29. Nickel (ug/l)		.01			
30. Nitrate (mg/l)		1.0			
31. pH	8.2	8.4			
32. Phosphate, Total (mg/l)		<.1			
33. Potassium (mg/l)			<1		
34. Selenium (ug/l)		<.005			
35. Silica (mg/l)	19	18			
(*) 36. Silver (ug/l)		<.005			
37. Sodium (mg/l)	194	210	200		
38. Solids, Dissolved (mg/l)	767	740	560		
39. Strontium (ug/l)		1			
40. Sulfate (mg/l)	261	210	<4		
41. Titanium (ug/l)		.1			
42. Vanadium (ug/l)		.001			
43. Yttrium (mg/l)		<.005			
44. Zinc (ug/l)		<.5			
45. Zirconium (ug/l)		<.005			
46. Radioactivity					
Gross Alpha (pcl)		4.2			
Radium 226*		.3			
Gross Beta (pcl)		0			
Thorium 230**					
Uranium**					
47. Total Organic Carbon (TOC)					
If TOC > 10 mg/l then measure					
Dissolved Organic Carbon		<1			
Suspended Organic Carbon					
Phenols					
Sulfur, Acid Extract					
Nitrogen, Base Extract					

(*) Not required

* Required if gross alpha is greater than 4 picocuries per liter (pcl).

** Required if gross beta is greater than 100 picocuries per liter (pcl).

at the end of a 4-hour pumping period on September 15, 1974, when the generator, transformers and pump were installed and tested. The second sample was collected after a preliminary pumping test of 15 hours. The third sample was taken after 23 days of pumping.

Major constituent analyses were done by Industrial Laboratories, Denver, Colorado; trace metals and total organic carbon by Commercial Testing & Engineering, Golden, Colorado; and radioactivity by Hazen Research, Inc., Golden, Colorado.

Total organic carbon was less than 1 mg/l. Gross beta was less than 100 pC/l. Gross alpha was greater than 4 pC/l; therefore, Ra₂₂₆ was determined and was found to be less than 4 pC/l.

The major change observed during the testing was in the sulfate content, which changed markedly from well over 200 mg/l initially, to less than 4 mg/l on into the test. This probably reflects the initial contribution of high sulfate water from the Evacuation Creek Member. A logical hypothesis would be that as water levels in the pumping well dropped, fractures in the Evacuation Creek Member were depleted and the sulfate content was diminished. Another change observed during the testing was in the fluoride content, which increased as testing progressed from initial levels of 2-4 mg/l to about 18 mg/l. Perhaps this reflects early dilution by very low fluoride content water in the uppermost level of the aquifer which was depleted as pumping continued and water levels dropped.

II B-7 Aquifer Data - Jetting Tests

A description of jetting test procedures and calculation methods was presented in Summary Report #1. During the second report period, jetting tests were run on wells SG-1, SG-17, SG-20 and SG-21 (Table II B-5).

II B-8 Aquifer Data - Drill Stem Tests & Multi-Packer Tests

Details of Testing

Prior to the commencement of drilling of SG-17, it was determined that a detailed horizontal permeability and water quality profile of Tract C-b subsurface conditions would be useful for many purposes. Mining engineers in particular, were concerned with these two important mine design factors. Therefore, it was decided to conduct drill stem tests at regular intervals as an integral part of the core hole drilling of SG-17. Two drill stem tests were also run in each of the core holes SG-20 and SG-21. Table II B-6 presents a summary of the drill stem test intervals for core holes SG-17, SG-20, and SG-21.

To conduct drill stem tests, at any given depth, a packer is lowered on drill pipe. The packer is set at some interval above the bottom

TABLE II B-5
JETTING TEST DATA

WELL	TEST NO.	DATE	DEPTH (ft.)	TRANSMISSIVITY, T; gal/day/ft.
SG-1	JT-1	11- 4-74	450	4570
	JT-2	11- 7-74	706	4075
	JT-3	11-12-74	1036	3880
	JT-4	11-14-74	1105	4440
	JT-5	12- 1-74	2227	5160
	JT-6	12- 6-74	2525	4620
SG-17	JT-1	11-10-74	859	113
	JT-2	11-27-74	1250	916
	JT-3	12- 1-74	1336	1374
SG-20	JT-1	12- 4-74	515	7.5
	JT-2	12-12-74	986	9350
SG-21	JT-1	12-16-74	576	9.5

TABLE II B-6

SUMMARY OF DRILL STEM TEST INTERVALS

SG-17

Drill Stem Test No.	Depth of Packers (Ft.)		Borehole Depth (Ft.)	Interval Tested (Ft.)	Stem Length (Ft.)	Zone Tested
	Upper Packer	Lower Packer				
1	380	386	436	386 - 436	50	Evacuation Creek
2	784	788	808	788 - 808	20	Evacuation Creek
3	818	822	869	822 - 869	47	Parachute Creek above A Groove
4	862	866	919	866 - 919	53	Parachute Creek above A Groove
5	915	919	970	919 - 970	51	Parachute Creek above A Groove
6	963	967	1017	967 - 1017	50	Parachute Creek above A Groove
7	1013	1017	1067	1017 - 1067	50	Parachute Creek above A Groove
8	1062	1066	1116	1066 - 1116	50	Parachute Creek above A Groove
9	1111	1116	1166	1116 - 1166	50	Parachute Creek above A Groove
10	1160	1164	1212	1164 - 1212	48	Parachute Creek above A Groove
11	1195	1200	1224	1200 - 1224	24	Parachute Creek A Groove
12	1211	1215	1224	1215 - 1224	9	Parachute Creek A Groove
13	1219	1224	1250	1224 - 1250	26	Parachute Creek above Mine Roof
14	1246	1251	1280	1251 - 1280	29	Parachute Creek Mine Roof
15	1275	1280	1309	1280 - 1309	29	Parachute Creek Mining Zone
16	1303	1308	1336	1308 - 1336	28	Parachute Creek Mine Floor
17	1323	1327	1374	1327 - 1374	47	Parachute Creek below Mine Floor
18	1369	1373	1419	1373 - 1419	46	Parachute Creek B Groove
19	1419	1423	1470	1423 - 1470	47	Parachute Creek below B Groove
20	1419	1423	1470	1423 - 1470	47	Parachute Creek below B Groove
21	1469	1473	1522	1473 - 1522	49	Parachute Creek below B Groove
22	1424	1428	1522	1428 - 1522	94	Parachute Creek below B Groove
23	1508	1514	1572	1514 - 1572	58	Parachute Creek below B Groove
24	1557	1561	1622	1561 - 1622	61	Parachute Creek below B Groove
25	1614	1618	1670	1618 - 1670	52	Parachute Creek below B Groove
26	1664	1668	1720	1668 - 1720	52	Parachute Creek below B Groove
27	1707	1711	1770	1711 - 1770	59	Parachute Creek below B Groove
28	1764	1768	1820	1768 - 1820	52	Parachute Creek below B Groove
29	1814	1818	1870	1818 - 1870	52	Parachute Creek below B Groove
30	1865	1869	1920	1869 - 1920	51	Parachute Creek below B Groove
31	1914	1918	1970	1918 - 1970	52	Parachute Creek below B Groove
32	1964	1968	2020	1968 - 2020	52	Parachute Creek above Lower Rich Zone
33	2014	2018	2070	2018 - 2070	52	Parachute Creek Lower Rich Zone
34	2116	2120	2170	2120 - 2170	50	Parachute Creek below Lower Rich Zone
35	2216	2220	2270	2220 - 2270	50	Parachute Creek below Lower Rich Zone
36A	2316	2320	2370	2320 - 2370	50	Parachute Creek below Lower Rich Zone
36B	2311	2315	2370	2315 - 2370	55	Parachute Creek below Lower Rich Zone
37	2391	2395	2460	2395 - 2460	65	Garden Gulch

BOREHOLE SG-20

1	892	896	945	896 - 945	49	Parachute Creek straddling A Groove
2	941	945	986	945 - 986	41	Parachute Creek above Mine Roof

BOREHOLE SG-21

1	966	1000	1036	1000 - 1036	36	Parachute Creek above Mine Roof
2*	946 950	1000	1036	950 - 1000	50	Parachute Creek above A Groove

* Test straddled the open hole, upper, middle and lower packers used.

of the hole and then water is jetted out of the drill pipe for some prearranged interval of time. After the jetting is terminated, the rise or recovery in water level in the packed-off zone is recorded. The horizontal permeability of that zone can then be calculated from the recovery data. The computation methods are similar to those used for standard jetting tests described in Quarterly Report #1.

Although substantially more expensive, the drill stem test has several important advantages over routine jetting tests:

- 1) It allows a direct calculation of horizontal permeability for a particular small interval in the hole.
- 2) It allows the collection of a water quality sample from a small discrete sub-surface interval.
- 3) It can be used to provide a permeability and water quality profile, or picture of how conditions change with depth. (Jetting tests provide only a composite picture of the entire open hole, at any particular time during drilling). Therefore, routine jetting tests were abandoned in favor of the more useful drill stem tests during the drilling of SG-17.

In addition to the standard, single packer drill stem tests, it was decided that more sophisticated multi-packer tests should also be included in the SG-17 drilling package. A three-packer tool was assembled in which water could be selectively withdrawn or injected into very small packed-off intervals. Attached to the bottom of the tool was a special device used to set the string of packers in the open hole. This special device and packers, in total, was called a "hook wall multi-packer assembly." Pressure sensing bombs were located above and below all of the packers, to detect changes in fluid pressures and to determine packer failure. The tool could be rotated at the surface, and the hook "set" into the rock of the well bore. The packers were then expanded and the test conducted. Table II B-7 lists the intervals tested by this method.

The major aspect of all three multi-packer test series (conducted on December 8, 1974; January 13, 1975; and January 14 to 15, 1975) was to inject water at rates of 5, 10, 20, and 20+ gallons per minute, into the primary packed off interval. The change in pressures in the various zones caused by this injection of water was recorded by the pressure bombs. After completing the injections the tool was loosened, raised to a higher interval, and another test run. Details on procedures and schematics of the tool may be found in Quarterly Report #2.

Horizontal permeabilities can be calculated from both drill stem test results and multi-packer test results, but the primary objective of the multi-packer testing was to determine vertical permeability. The configuration of the tool and packer assembly permits the collection of pressure data which theoretically can be reduced to yield vertical permeability values. It is of great

TABLE II B-7

SUMMARY OF MULTIPLE-PACKER TEST INTERVALSBOREHOLE SG-17

<u>Test No.</u>	<u>Depth of Packers (Feet)</u>			<u>Borehole Depth (Feet)</u>	<u>Interval Tested (Feet)</u>	<u>Zone Tested</u>
	<u>Upper</u>	<u>Middle</u>	<u>Lower</u>			
1-1	1372	1387	1403	1470	1372 - 1403	Parachute Creek below Mine Floor
1-2	1249	1265	1280	1470	1249 - 1280	Parachute Creek Mine Roof
1-3	1155	1171	1186	1470	1155 - 1186	Parachute Creek above A Groove
1-4	1115	1130	1146	1470	1115 - 1146	Parachute Creek above A Groove
2-1	1362	1386	1410	2460	1362 - 1410	Parachute Creek below Mine Floor
2-2	1184	1208	1232	2460	1184 - 1232	Parachute Creek straddling A Groove
3-1	1422	1447	1472	2460	1422 - 1472	Parachute Creek below B Groove
3-2	1184	1209	1234	2460	1184 - 1234	Parachute Creek straddling A Groove
3-3	1147	1172	1197	2460	1147 - 1197	Parachute Creek above A Groove
3-4	1123	1148	1173	2460	1123 - 1173	Parachute Creek above A Groove
3-5	1338	1363	1388	2460	1338 - 1388	Parachute Creek below Mine Floor
3-6	1089	1114	1139	2460	1089 - 1139	Parachute Creek above A Groove

importance to be able to establish the probable rate of water inflow from the roof of the C-b underground mine, and this involves both horizontal and vertical permeabilities. The calculated horizontal permeabilities from SG-17 drill stem tests and multi-packer tests are presented in Tables II B-8 and II B-9 respectively. (Table II B-10 similarly presents the same information for the drill stem tests in core holes SG-20 and SG-21.) The test results indicated that vertical permeability is some fraction less than the horizontal permeability, although it could not be positively quantified. Data from many of the multi-packer tests also showed evidence of packer failure and therefore could not be quantitatively analyzed for vertical permeability. This led to the conclusion that multi-packer testing probably cannot give absolute values for vertical permeability on Tract C-b.

With regard to the water quality data collected during the drilling of SG-17, it can be concluded that the water beneath the SG-17 location is stratified into a series of small aquifers separated by unfractured rich oil shale zones. The water in the upper strata can generally be characterized as being of good quality. However, below 1800 feet the character of the water changed and small isolated intervals of saline water were encountered. This leads to the inference that the saline water at depth, beneath the Mahogany zone under Tract C-b is confined and is not able to migrate upward. Preliminary data from the lower zone phase of the pumping test at AT-1 tend to corroborate this inference.

II B-9 Aquifer Data - Pumping Tests

Pumping Test of AT-1

The C-b Shale Oil Project has now completed the upper zone phase of the pumping test of AT-1. The test was done for two principal reasons:

1. To fulfill the requirement of the Federal Oil Shale Lease regarding pump tests of water bearing zones; and
2. To evaluate the ground water hydrology of Tract C-b for mine engineering purposes.

In the Exploration Plan submitted for Tract C-b, it was proposed to drill one major test well, AT-1, in the center of the Tract and test the upper zone and lower zone aquifers, above and below the Mahogany zone respectively. Drilling of the test well AT-1 commenced on June 15, 1974. It was drilled at a diameter of 12¼ inches to a depth of 1338 feet, just a short distance into the Mahogany zone. Steel casing was set in the hole and a diesel generator powered submersible pump was lowered to the bottom of the hole in preparation for the start of pumping.

TABLE II B-8

HORIZONTAL PERMEABILITY CALCULATIONS
SG-17 Drill Stem Tests

Tract C-b, Rio Blanco County, Colorado

DST No.	Interval feet	Permeability md.	Remarks
1	386-436		Did not analyze
2	788-808		Did not analyze
3	822-869	11.0	
4	866-919	12.7	
5	919-970	34.0	
6	967-1017	10.7	
7	1017-1067	19.9	
8	1066-1116	20.0	
9	1116-1166	8.0	
10	1164-1212	185.0	
11	1200-1224	21.2	
12	1215-1224	20.8	
13	1224-1251	300.	
14	1251-1271	8.0	
15	1280-1309	13.0	
16	1309-1336		Data scattered
17	1327-1373	52.	
18	1373-1419	15.	
19	1423-1470		Test failed
20	1423-1470	23.9	
21	1473-1522	3.0	
22	1428-1522	4.7	
23	1512-1572	4.0	
24	1561-1572	23.0	
24 (J)	1561-1622		No pressure data. Equipment problem.
25	1618-1640	4.0	
25 (J)	1618-1670	1.6	
26	1668-1679	30.0	
26 (J)	1668-1720	7.3	
27	1711-1770	6.0	
28	1768-1779	42.0	
28 (J)	1768-1820	9.8	
29	1818-1870	2.0	
30	1869-1880	275.	
30 (J)	1869-1920	30.	

J = Jetting Test

TABLE II B-8 (Continued)

HORIZONTAL PERMEABILITY CALCULATIONS
SG-17 Drill Stem Tests

C-b Tract, Rio Blanco County, Colorado

<u>DST No.</u>	<u>Interval feet</u>	<u>Permeability md.</u>	<u>Remarks</u>
31	1918-1970	4.0	
32	1966-2020	169.	
33	2018-2070		No injection
34	2120-2170	30.	
35	2220-2270		No injection
36A	2320-2370		No injection
36B	2315-2370		No injection
37	2395-2460	35.	

J = Jetting Test

TABLE II B-9

HORIZONTAL PERMEABILITY CALCULATIONS
Core Hole SG-17
Tract C-b, Rio Blanco County, Colorado

Multi-Packer Tests

<u>MPT No.</u>	<u>Series</u>	<u>Interval feet</u>	<u>Permeability md.</u>	<u>Remarks</u>
1	11210-LL	1089-1114	75	
2	11210-LL	1123-1148		Packer apparently leaked, or bad gauge
3	11210-LL	1147-1172	92.	
4	11210-LL	1184-1209		Middle packer apparently leaked
5	11210-LL	1338-1363		" "
6	11210-LL	1422-1447		" "

TABLE II B-10

HORIZONTAL PERMEABILITY CALCULATIONS

SG-20

Tract C-b, Rio Blanco County, Colorado

<u>DST No.</u>	<u>Interval feet</u>	<u>Permeability md.</u>	<u>Remarks</u>
1	848-894		Injected at unknown rate.
2	945-986		Insufficient decline data

SG-21

C-b Lease, Rio Blanco County, Colorado

<u>DST No.</u>	<u>Interval feet</u>	<u>Permeability md.</u>	<u>Remarks</u>
2	950-1000		No injection information
1	1000-1036	20.	

Initially, the test was designed with close-in observation wells only. A thorough review by the operator and other venture participants, however, produced the recommendation that additional zones should be monitored--particularly to determine the vertical leakage factor through the Mahogany. Also, it was decided to add three distant observation wells, completed above and below the Mahogany zone. This gave a total array of four close-in wells and three distant wells. Three of the close-in wells (AT-1a, AT-1c, and AT-1d) were randomly spaced around AT-1. One well (AT-1b) was positioned along the primary fracture trend, North 70° West. (See Figure II B-11.)

By the time a decision had been reached to monitor three zones, AT-1a and SG-10 had already been drilled and could not be completed to monitor all three of the desired intervals. Therefore, two twin holes were drilled, AT-1al and SG-10a, to monitor the upper zone aquifer and complete the monitoring package. The distant wells SG-11, SG-6, and SG-10, had originally been designed as core holes only. As a result of the hydrology considerations, however, they were cored and then completed as ground water observation wells for the pumping test. Table II B-11 presents monitored zone and location information for each of these drilled holes.

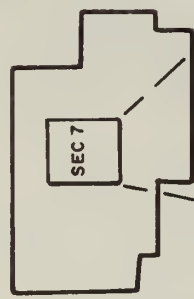
As the summer drilling season progressed, the complexity and sophistication of the pumping test continued to increase. Well completion techniques had to be designed for each of the multi-zone wells. Up to three strings of small diameter 2-3/8 inch steel tubing were set into each open core hole or well and cemented in place. Once installed the strings were selectively perforated to monitor either the upper aquifer, the lower aquifer, or a zone called the Mahogany Vugular at the base of the mining interval. (See Figure II B-12.) Quarterly Report #1 contains much of the data which document these efforts. Eventually, all of the wells were drilled and completed, and by October the generator and pump appeared ready to go.

In mid-October, however, two new problems emerged. Observation well AT-1b was logged and holes were discovered in the casing strings. The well had been considered quite important since with respect to AT-1, it was oriented along the North 70° West fracture trend. This concern resulted in the implementation of an extensive program to salvage AT-1b. One of the strings was eventually salvaged to monitor the upper zone aquifer; the other two were abandoned and were not used during the test.

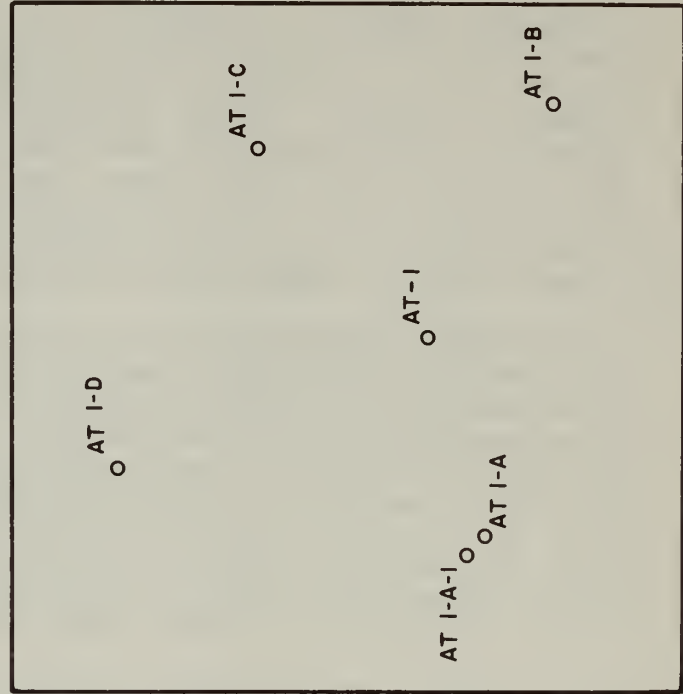
A second problem developed when the Sperry-Sun permagauges were installed. The surface recorders appeared to be sensitive to unknown natural causes. Temperature change, in particular, caused at least some of the problem. Insulated heating sheds were therefore constructed at each well location to eliminate any possible temperature fluctuations. Also, the recorders needed AC power and the test could not commence until power lines were installed and/or appropriate battery packs prepared. The power situation was eventually overcome, and the pumping equipment was given a trial run. (As a

FIGURE II B-II

PUMP TEST



AQUIFER PAD



T 3 S

SEC 7
O SG-6

AT-1
O

SG-11
O

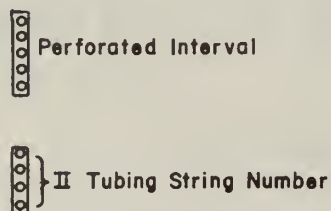
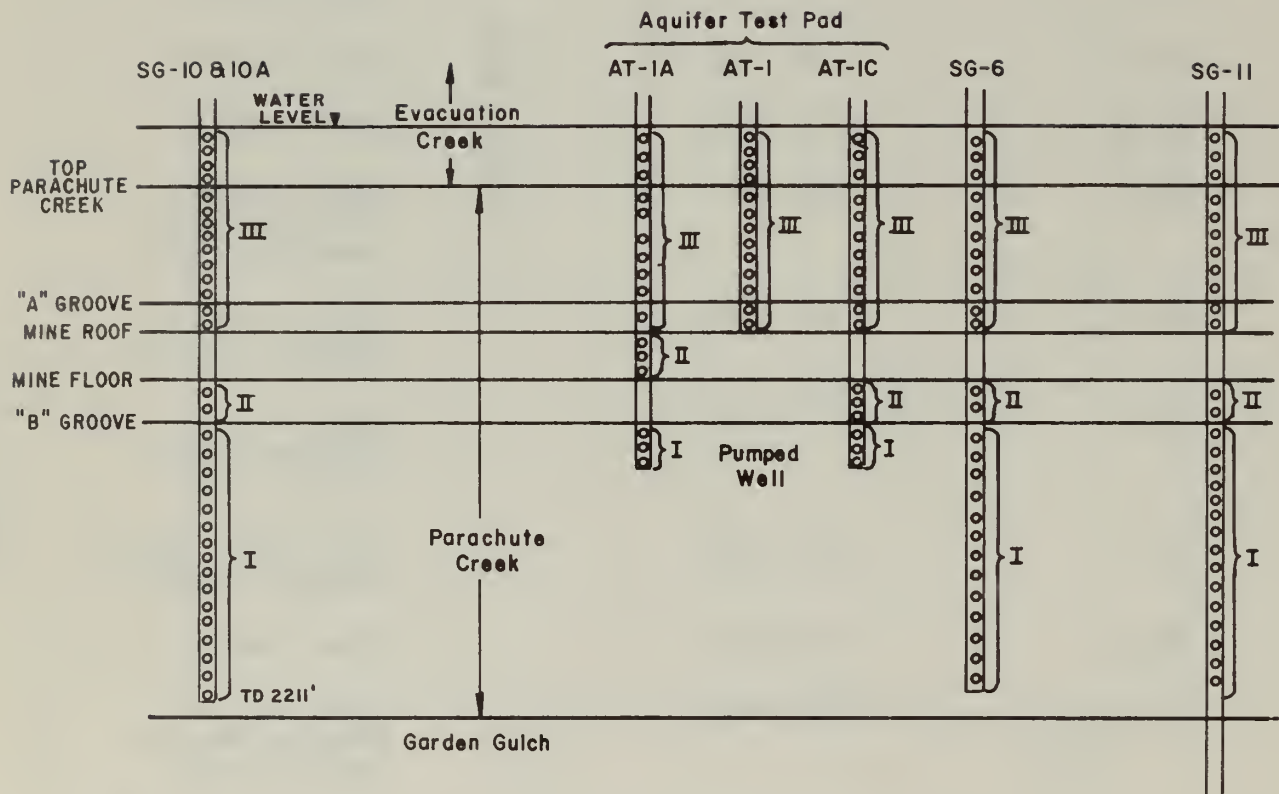
SG-10
O

TABLE II B-11
AQUIFER TEST OBSERVATION WELL DATA

<u>WELL NO.</u>	<u>DISTANCE (FEET) FROM AT-1</u>	<u>ZONES MONITORED</u>
AT-1	-	Upper Aquifer
AT-1a	79 feet	Lower Aquifer Mining Zone
AT-1a1	85 feet	Upper Aquifer
AT-1b	102 feet	Upper Aquifer
AT-1c	102 feet	Upper Aquifer Mahogany Vugular Lower Aquifer
AT-1d	127 feet	Upper Aquifer Mahogany Vugular
SG-6	1289 feet	Upper Aquifer Mahogany Vugular Lower Aquifer
SG-10	2339 feet	Lower-lower Aquifer Mahogany Vugular
SG-10a	2350 feet	Upper Aquifer
SG-11	3236 feet	Upper Aquifer Mahogany Vugular Lower Aquifer

Mahogany Vugular is the interval between the base of the Mining Zone and the B groove.

FIGURE II B-12



**SCHEMATIC CROSS-SECTION
UPPER AQUIFER PUMP TEST
C-b TRACT, COLORADO**

SCALE: None

note, it was necessary to secure a fuel allocation from the regional office of the Federal Energy Administration of 30,000 gallons of diesel fuel per month to supply the 40 KW generator which powered the submersible pump.)

On November 20, the Sperry-Sun instruments were officially turned on to record background pressure, prerequisite to commencing the pumping test. This was done to document any barometric effects or other cyclic water level changes caused by natural events. After background readings were collected for approximately ten days, the pump was turned on November 30, 1974 at 9:07 A.M.

A chronology is given below which lists the sequence of events after that date. An initial pumping phase of 24 days was followed by a recovery phase of five days, and closed with a pulse pumping phase of five days. Recovery was observed in AT-1 for 13 days after the pulse, until the pump was pulled for deepening of the well. Pressure responses were observed continuously in the other observation wells, however, through the period. Pin hole leaks developed in several of the permagauges during the test, but no other significant or major problems were encountered.

Sequence of Events

Upper Aquifer Pump Test

Pump on @ 9:07 A.M., November 30, 1974, Initial Drawdown Phase

Pump off @ 9:07 A.M., December 23, 1974, Initial Recovery Phase

Pump on @ 9:07 A.M., December 28, 1974, Pulse Drawdown

Pump off @ 9:07 A.M., January 2, 1975, Final Recovery

End of Test, January 15, 1975

Begin Deepening of Well into Lower Aquifer for Lower Aquifer Pump Test

Hydrologists had previously determined during the drilling of AT-1 that the water produced by the pumping well would probably have less than 1000 mg/l of dissolved solids. This was substantiated during the test. The sulfate content and fluoride content, however, changed as the test progressed. These changes are discussed in Section II B-6 of this report. A two acre-foot holding pond had been constructed at the aquifer test site to be used in the event that poor quality water was encountered. The pond was never used because the dissolved solid content of the AT-1 discharge was quite low. Discharge water was collected in a ditch at the well head and spread across the adjacent hillside below. Eventually, some of the discharge water did reach Piceance Creek via Cottonwood Gulch (normally dry) and U.S.G.S. field technicians collected a sample at that station on December 4, 1974. (The analytical results are

included in Section II A-1, Surface Streams, of this report.) For all intents and purposes the chemical quality of their sample is identical to that of the ground water sample collected at the AT-1 well head on December 23, 1974. The data for that well head sample are included in Section II B-6, Water Quality - Pump Tests, of this report. The U. S. G. S. data also indicated that less than one-half of the well discharge reached Piceance Creek. The majority of the discharge water seeped into the two miles of dry stream bed between AT-1 and the gauging station on Cottonwood Gulch.

Throughout the test, field technicians monitored the conductivity of discharge water. The conductivity remained below 1500 micromhos per centimeter throughout the test. The initial pumping rate averaged over 400 gallons per minute, but the rate fell off as water levels were drawn down. Eventually, the discharge stabilized at 356 gallons per minute.

Results of the Pumping Test: The pressure responses from the seven upper zone monitoring strings document water level changes within a complex fractured rock system. Reservoir simulation experts have divided the simplified upper zone-lower zone aquifer system into several layers of individual units - based on jetting test data, core data, rock compressibility, and geologic interpretation. Pressure response histories from the test are currently being input to this multi-layered model. Eventually, the model will be modified to account for the pressure changes observed during the pumping test. Once this is done and the pressure responses are "matched," the impacts of the ground water system on an underground mine can be defined. These data will help to determine the effective porosity and permeability of the upper zone aquifer. This information will lead to a value for capacity, or gross water production potential. Table II B-12 presents the initial transmissivities and storage coefficients calculated from results of the Pumping Test. Summary Report #1 (pages 32 - 34) contains a discussion of the method used to calculate these values.

The primary conclusion deduced from the upper aquifer pumping test is that under Tract C-b (in the vicinity of Section 7, at least) the Mahogany zone of rich oil shale completely separates ground water above it from ground water below it. No pressure changes were observed in any of the lower strings in any well - in spite of the fact that water levels were drawn down in the upper aquifer several hundred feet at AT-1 and up to 60 feet at SG-11, the most distant observation point. The project's reservoir simulation group has determined that the vertical permeability of portions of the Mahogany zone is less than .1 millidarcy, making them essentially impermeable. The test data also show that directional permeability exists in the upper zone aquifer. Water levels in the upper string of SG-11 responded after only ten hours of pumping. Hydrologists had some doubt as to whether it would respond at all, because of the distance from AT-1 (over 3000 feet). The orientation of the directional permeability, AT-1 to SG-11, coincides with several major linements present on the Tract, i.e., stream orientation, etc.

TABLE II B-12

Transmissivity (T) (g/d/ft) and Storage Coefficients (S) (Shallow Aquifer)

Well No.	24-day Drawdown	5-day Recovery	5-day Drawdown	Final Recovery
AT #1	T = 690 initial T = 1850 secondary T = 804 tertiary No Storage Coefficient Calculation	T = 1850 secondary T = 1130 tertiary No Storage Coefficient Calculation	T = 650 initial T = 1380 secondary T = 1090 tertiary No Storage Coefficient Calculation	T = 241 initial T = 2391 secondary T = 1197 tertiary No Storage Coefficient Calculation
AT #1A-1	T = 1300 S = 5.6x10 ⁻⁴	T = 2260; S = 3.58x10 ⁻⁴ T = 1068; S = 5.91x10 ⁻⁴	T = 1475; S = 4.34x10 ⁻⁴	T = 2513; S = 3.19x10 ⁻⁴ T = 1100; S = 8.37x10 ⁻⁴ T = 1356; S = 4.10x10 ⁻⁴
45 AT #1B	T = 1186; S = 6.4x10 ⁻⁴	T = 1132; S = 5.44x10 ⁻⁴	T = 1368; S = 3.78x10 ⁻⁴	T = 1718; S = 4.13x10 ⁻⁴ T = 1130; S = 5.84x10 ⁻⁴
AT #1C	T = 1117; S = 3.6x10 ⁻⁴	T = 1313; S = 1.08x10 ⁻⁴	T = 1123; S = 2.70x10 ⁻⁴	T = 1339; S = 1.02x10 ⁻⁴ T = 1100; S = 1.65x10 ⁻⁴ T = 1356; S = 5.98x10 ⁻⁴
AT #1D	T = 1103; S = 4.13x10 ⁻⁴	T = 1161; S = 1.80x10 ⁻⁴	T = 1156; S = 4.03x10 ⁻⁴	T = 1938; S = 1.50x10 ⁻⁴ T = 1146; S = 2.04x10 ⁻⁴ T = 1356; S = 9.28x10 ⁻⁵
SG #6	T = 4300; S = 1.09x10 ⁻³ T = 2060; S = 8.16x10 ⁻⁴	T = 7978; S = 1.80x10 ⁻³	T = 16,250; S = 4.59x10 ⁻³	T = 6060; S = 2.87x10 ⁻³ T = 3836; S = 3.03x10 ⁻³
SG #10A	T = 8968; S = 4.84x10 ⁻⁴ T = 2400; S = 3.23x10 ⁻⁴ T = 1220; S = 4.39x10 ⁻⁴	T = 6760; S = 4.36x10 ⁻⁴	T = 1880; S = 1.44x10 ⁻⁴	T = 6572; S = 5.4x10 ⁻⁴ T = 2493; S = 7.22x10 ⁻⁴
SG #11	T = 15,500; S = 1.20x10 ⁻⁴ T = 2525; S = 5.64x10 ⁻⁵ T = 1150; S = 5.34x10 ⁻⁵	T = 9037; S = 9.74x10 ⁻⁵ T = 2693; S = 7.20x10 ⁻⁵	T = 3692; S = 8.88x10 ⁻⁵	T = 2950; S = 1.02x10 ⁻⁴ T = 1615; S = 1.43x10 ⁻⁴

The test also led to additional hydrological studies at SG-17 (see Section II B-8, Drill Stem Tests, of this report) and SG-1 (data and results will be included in Quarterly Report #3). The lower zone phase of the pumping test commenced on February 21, 1975 and to date, appears to substantiate the upper zone results.

II B-10 Lithologic Log Data

The lithologic logs present a description of rock types encountered in a core hole. The detail of description varies with depth and operation. In all cases, however, the lithology is described from drill cuttings on ten-foot intervals above the cored interval. In the zones that are cored, the lithology is described from the core on one-foot intervals.

In addition to providing a means for describing lithology, the lithologic log presents information on structural dip, joints, fractures, and general rock quality. These data are recorded on the lithologic log at the appropriate depth.

A field lithologic log has been made on each well drilled. Table II B-13 shows those wells for which a lithologic log is included in either Quarterly Report #1 or Quarterly Report #2.

II B-11 Geophysical Log Data

Two types of geophysical logs are required to be run on test holes. They are the sonic log and resistivity log. As of September 12, 1974, the Area Oil Shale Supervisor specified that the resistivity log should be either a standard electric resistivity log or focused electric resistivity log (laterolog or dual laterolog) rather than the induction-type log. In addition to the required sonic and resistivity logs, other types of geophysical logs have been run. Table II B-14 shows the geophysical logs which are included in Quarterly Report #2.

II B-12 Core Assay Data

Assays of core samples are run to determine:

- (1) shale oil yield
- (2) soluble sodium
- (3) alumina

For the determination of shale oil content, cores are sampled on one-foot intervals and these samples are subjected to laboratory analysis. Each sample is retorted through a specified time curve to yield data on oil content in gallons per ton, water content in gallons per ton, and residue weight in pounds per ton. In addition, gas-plus-loss is calculated for each sample.

TABLE II B-13

LITHOLOGIC LOGS

ALLUVIAL WELLS		AQUIFER TEST WELLS		CORE HOLES	
A-1	1	AT-1	1	SG-1	1
A-2	1	AT-1a	1	SG-1a	2
A-3	1	AT-1a1	1	SG-6	1
A-4	1	AT-1b	1	SG-8	1
A-5	1	AT-1c	1	SG-9	1
A-6	1	AT-1d	1	SG-10	1
A-7	2			SG-10a	1
A-8	1			SG-11	1
A-9	1			SG-17	2
A-10	1			SG-18	1
A-11	1			SG-18a	1
A-12	1			SG-19	1
A-13	1			SG-20	2
				SG-21	2
				Cb-2b	1

1, 2 = Indicates Quarterly Report in which litholog is included.

TABLE II B-14

GEOPHYSICAL LOGS INCLUDED IN QUARTERLY REPORT #2

Well	SG-1	SG-1a	SG-8	SG-9	SG-17	SG-20	SG-21
Log (Schlumberger)							
Sonic	X		X				
Sonic, Bore hole Compensated	X		X	X	X	X	X
Laterolog	X		X	X			
Dual Laterolog	X				X		X
Formation Density	X	X	X	X	X	X	X
Temperature	X		X	X	X	X	X

Analysis for sodium is done only in the R-4 zone (on one-foot intervals), and analysis for alumina is done in both the Mahogany and R-4 zones on one-foot intervals. (See Figure II B-2 on page 16 for location of the zones.) Sodium content is determined by leaching raw shale in water and measuring the dissolved sodium content by atomic absorption. Alumina is determined by leaching spent shale with sodium hydroxide solution and measuring the soluble alumina by atomic absorption. Alumina in spent shale is then corrected back to a raw shale basis using the Fischer assay weight loss. The laboratory data sheets for those wells on which assays were completed in the past quarter are included in Quarterly Report #2.

Table II B-15 lists all assay data which have been included in quarterly reports to date.

II B-13 Core and Cuttings Trace Element Analysis

The Conditions for Approval for the Core Drilling and Associated Ground Water Program require "sampling of drill cuttings or core with subsequent analysis to determine occurrence of arsenic, antimony, boron, cadmium, fluoride, mercury, and selenium" until it has been determined that additional sampling and analysis would not be of significant value.

Complete information has now been developed for four wells spaced across the tract. The four wells chosen for analysis are SG-8, SG-9, SG-10 and AT-1a1; and the laboratory data sheets are included in Quarterly Report #2. Project geologists are currently assimilating these data into a composite in order to provide a "cross-section" view of the tract. Such a view will aid in determining the necessity for continued detailed analyses.

II B-14 Rock Mechanics

Rock mechanics test data are being obtained and analyzed by Golder Associates, Inc. No reports beyond those presented in Quarterly Report #1 have been received in time for inclusion in Quarterly Report #2. It is expected that Quarterly Report #3 will contain more rock mechanics data.

II B-15 Gas Determination and Analysis - Tract C-b Gas Sampling Program

Purpose

The basic purpose of the C-b gas sampling program is to obtain enough information concerning occurrence of methane or other gases on the C-b lease tract to allow proper evaluation of the feasibility and economics of underground mining on the Tract.

TABLE II B-15

CORE ASSAY DATA

Core Hole	Oil	Sodium	Alumina
AT-1A	1	1	1
SG-9	2	2	2
SG-10	1	1	1

1, 2 = Indicates Quarterly Report in which data are located.

Discussion

In achieving the objective above, we do not have the advantage of information from, or past experience in, mines in the same area to guide us. As a result, the approach must be taken that any opportunity to gather data should be taken advantage of. Of necessity, an approach of attempting to gather all data available must be used, sometimes without a clear idea of how useful the data obtained will be. As a result, it becomes extremely important to analyze and interpret the data as soon as data are available in order to modify existing programs and develop new ones as the need becomes apparent. With this type of approach, a general picture of gas occurrence and characteristics should be obtained, hopefully in enough detail to allow some sort of quantitative evaluation of gas influx into an underground mine on the Tract.

In order to obtain this information, there are several areas in which data are being gathered. These are as follows:

(1) Vertical and NQ (slant) core drilling

Gas samples are being taken as specified by the lease stipulations. (Refer to Quarterly Report #1.) In addition, Baroid gas detectors are being used to provide a continuous record of gas concentration during the drilling operation.

(2) Core Testing

Core samples are now being tested through the use of a procedure outlined in U. S. Bureau of Mines Report of Investigation RI 7767 ("The Direct Method of Determining Methane Content of Coal Beds for Ventilation Design" by F. N. Kissell, C. M. McCulloch, and C. H. Elder, 1973) to evaluate gas content.

(3) Aquifer Test

Data concerning gas content in water pumped during the aquifer test were gathered using a gas-water separator and gas metering equipment.

Data gathered from the above sources are incomplete at present, and no analysis, interpretation or evaluation of the data has yet been made. In the interest of presenting useful and comprehensive information, rather than a fragmented package of incomplete data, no data from the gas sampling programs listed above are included in this report. An interim report on the gas sampling program is currently being prepared and should be ready for inclusion in Quarterly Report #3.

Included in Quarterly Report #2 is a complete summary of all gas bomb samples and Baroid gas plots compiled from November 30, 1974 to February 24, 1975. These data are presented in the same form as that in Quarterly Report #1 and should be used in a qualitative sense only. Refer to Summary Report #1, pages 44 and 45, for an example of the available data.

II C AIR QUALITY

The Tract C-b Air Quality Program is concerned with both measurements of atmospheric constituents and meteorological processes which affect their transport and diffusion. Experimental program areas include air quality and surface meteorology, low altitude meteorology, upper air studies and visibility. In addition, predictive modeling studies relating to plant design will be conducted to evaluate the effects of commercial operations on ambient air quality.

II C-1 Air Quality and Surface Meteorology

The Oil Shale Lease Environmental Stipulations require monitoring of air quality data over at least 90% of the Lease year at four stations, one of which is at (or as near as practicable) the expected point of maximum concentrations. Sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and suspended particulates are required to be monitored at all stations. Monitoring of total hydrocarbons (THC), methane (CH_4), non-methane hydrocarbons (NMHC), carbon monoxide (CO), ozone (O_3), oxides of nitrogen (NO_x), nitrogen dioxide (NO_2), and nitric oxide (NO), at one site is required by the Area Oil Shale Supervisor's Conditions for Approval.

*except this
to be the main
met facility
@ 95% reporting*

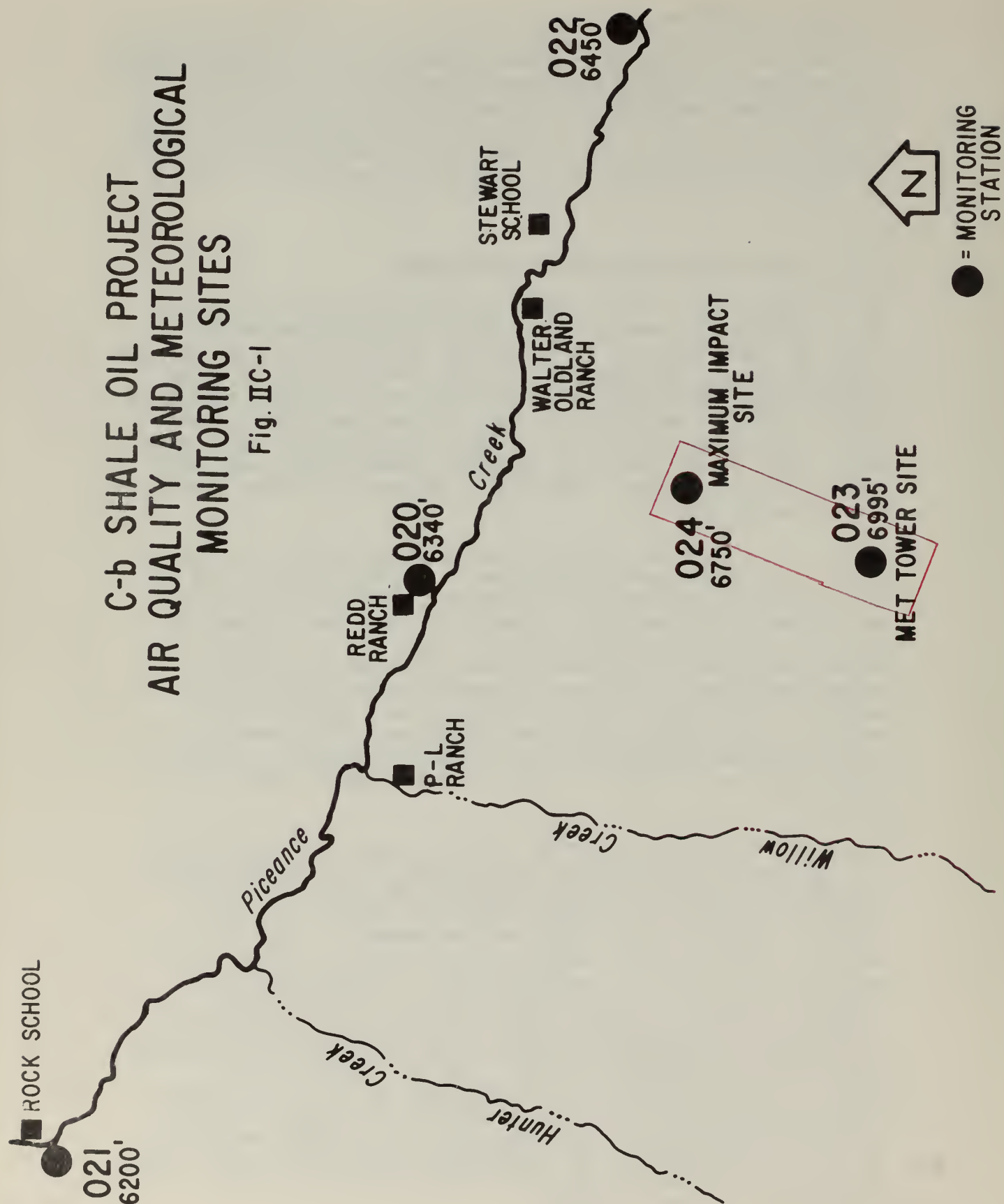
Figure II C-1 is a map indicating the locations of five air quality trailers and the meteorological tower. Trailers 020, 021, and 022 are located in the Piceance Creek valley at Redd Ranch, Rock School and the Gerald Oldland Ranch, respectively; trailers 023 and 024 are on the Tract at the meteorological tower and on the ridge between Cottonwood and Sorghum Gulches, respectively. The trailers and meteorological tower were designed by Radian Corporation of Austin, Texas, and are being operated and maintained by Radian personnel. Data reports from the consultants in the areas of air quality and low altitude meteorology (Radian Corporation and The Oil Shale Corporation Laboratories), are presented in Quarterly Report #2.

The hydrocarbon levels presented in these reports for trailer 023 for September through December do not appear to be entirely representative, due to a contaminated sampling manifold. The Hi-Vol particulate samplers' collection cycles are controlled by the trailer's computer system, which was programmed to terminate the sampling cycle if a power failure of more than 30 minutes occurred any time during a 24-hour sampling period. Intermittent power failures and failures of the back-up battery system occurred throughout the first quarter period, which resulted in the loss of a substantial amount of particulate data. Daily particulate samples were collected in December; however, due to a malfunctioning balance, pre-collection filter weights were in error and the mass loadings could not be accurately determined. We have requested that Radian approximate an average pre-collection filter weight and use this to determine the particulate mass loading for these months. If these data become available they would be reported with a disclaimer as to their accuracy.

*Roger, how does
this affect
90% data
collection
factor?*

C-b SHALE OIL PROJECT AIR QUALITY AND METEOROLOGICAL MONITORING SITES

Fig. IIC-1



Tables II C-1 through C-5 summarize the maximum concentrations for the gases and particulates from September through November that correspond to the appropriate time intervals determined by State and Federal regulations. Tables II C-6 through C-10 report similar data for the month of December.

Monthly averages for total hydrocarbons and ozone at trailer 020 indicate a slight decrease from September to December. The remaining gases at most of the other trailer sites indicate a decreasing trend from September through November, but with the December data indicating some increase for most gases. The monthly diurnal averages for ozone at trailer 020 indicate a consistent peak at approximately 1000-1800 hours for the four months. The diurnal trend for this gas at trailer 023 is not as pronounced, but demonstrates a slight decrease throughout the day on a monthly average.

Generally, during the period of September through November, the sulfur dioxide and hydrogen sulfide are higher at the Piceance Valley stations than on the Plateau. Trailer 021 consistently measures the highest concentrations during the period. In December, however, the highest concentrations are measured at the two Plateau trailers, 023 and 024. The December monthly high for sulfur dioxide and hydrogen sulfide occurred at trailer 023.

The quarterly composite patterns as determined by the bi-variate frequency distribution for wind direction vs. concentrations are very much influenced by the high concentration for most of the gases measured in September. A by-the-month examination of these patterns for the five trailer sites does not reveal a consistent pattern that would allow ready interpretation or determination of possible pollutant sources.

Particulate samples of 24-hour duration are obtained from Hi-Vol samplers utilizing fiberglass filters. The frequency distribution of the number of these particulate concentrations (in $\mu\text{g}/\text{m}^3$) by trailer is presented in Table II C-11. Every sixth day a 24-hour particulate sample on a cellulose filter is obtained for trace elements and radioactivity; the quarterly composite of these filters are also screened for trace elements and radioactivity. In addition, volatile trace metals are collected and analyzed by special techniques. The minimum detectable limits for the volatile tract metal analyses were: selenium $0.05 \mu\text{g}$, arsenic $0.5 \mu\text{g}$, and mercury 0.1 ng . The ambient concentrations of these volatile metals collected on January 28, 1975, were below the sensitivity of the analytical methods and are presented in Quarterly Report #2.

Regarding near-surface meteorology, the following paragraphs highlight both the variability of wind patterns throughout the day and the nature of large horizontal temperature gradients which can exist concurrently with surface temperature inversions in the valleys.

Wind patterns throughout one "typical" day are shown on Figure II C-2 in miles-per-hour units at the five trailer locations. Note that the down-valley direction for sites in the Piceance Creek (020, 021,

TABLE II C-1 QUARTERLY SUMMARY (SEPTEMBER '74 - NOVEMBER '74)
(Concentrations in Micrograms per Cubic Meter)

TRAILER NO. 020

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO ₂	3.8	103.6	9/14 (16:00)			146.0	9/14 (16:05)	226.3 ²	9/18 (4:35)	264.4	9/14 (17:00)
H ₂ S	0.5							10.1	11/9 (20:00)	47.1	9/13 (15:30)
Particulates +	8.2 ¹	133	11/29								
Total Hydrocarbons	899.					1847.5	10/7 (6:00)			2995.0	10/15 (12:50)
CH ₄	826.1					1712.5	9/7 (6:00)			2995.0	10/15 (12:50)
Non-CH ₄ Hydrocarbons	73.4					197.6	11/25 (6:00)			1950.4	10/25 (18:10)
O ₃	47.4							139.4	9/30 (5:25)	574.6	9/30 (6:05)
NO _x	7.0							103.3	9/30 (15:55)	672.7	9/30 (16:05)
NO	1.7							44.3	11/10 (5:50)	74.9	10/6 (12:55)
CO	833.8			2023.0	10/4 (18:55)			4483.8	10/7 (5:50)	5661.8	10/17 (17:45)
NO ₂	5.0							102.2	9/30 (15:55)	672.7	9/30 (16:05)

1 - Geometric Mean, 2 - 30-Minute Averaging Time, *Start of interval of occurrence.

+ Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-2 QUARTERLY SUMMARY (SEPTEMBER '74 - NOVEMBER '74)
(Concentrations in Micrograms per Cubic Meter)

TRAILER NO. 021

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO ₂	3.0	136	9/10 (22:00)			233/1	9/11 (12:30)	269.6 ²	10/7 (13:00)	742.1	9/11 (4:25)
H ₂ S	2.6							130.9	10/28 (20:00)	317.1	9/30 (17:30)
Particulates +	9.3 ¹	71.0	11/21								
Total Hydrocarbons											
CH ₄											
Non-CH ₄ Hydrocarbons											
O ₃											
NO _x											
NO											
CO											

1 - Geometric Mean, 2 - 30-Minute Averaging Time, *Start of time interval of occurrence.

+ Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-3 QUARTERLY SUMMARY (SEPTEMBER '74 - NOVEMBER '74)
(Concentrations in Micrograms per Cubic Meter)

TRAILER NC 022

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO ₂	6.0	113.5	9/29 (20:00)			254.6	9/30 (2:55)	707.9 ²	9/15 (0:10)	1726.4	9/15 (0:35)
H ₂ S	0.6							14.1	10/1 (3:30)	1125.4	9/25 (17:30)
Particulates +	11.3 ¹	154.0	11/28								
Total Hydrocarbons											
CH ₄											
Non-CH ₄ Hydrocarbons											
O ₃											
NO _x											
NO											
CO											

¹ - Geometric Mean, 2 - 30-Minute Averaging Time, *Start of time interval of occurrence.

+ Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-4 QUARTERLY SUMMARY (SEPTEMBER '74 - NOVEMBER '74)
(Concentrations in Micrograms per Cubic Meter)

TRAILER NO. 023

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO ₂	1.75	17.2	10/11 (3:00)			39.9	10/15 (15:20)	52.5 ²	10/21 (16:55)	205.8	10/21 (17:25)
H ₂ S	0.0							121.5	10/26 (13:15)	161.9	10/6 (18:10)
Particulates +	10.5 ¹	26.0	11/27								
Total Hydro- ** carbons	1064.6					18330.8	10/1 (6:00)			40376.3	11/21 (16:53)
CH ₄	149.7					13989.8	10/1 (6:00)			21338.9	10/7 (0:05)
Non-CH ₄ Hydrocarbons	933.0					17151.9	11/23 (6:00)			39816.2	11/22 (6:45)
O ₃	--							104.5	10/2 (17:10)	216.9	10/2 (7:00)
NO _x	6.7							181.2	9/29 (8:50)	270.5	9/29 (9:20)
NO	4.4							124.5	10/1 (1:05)	432.4	9/28 (14:40)
CO	3703.6			14098.2	11/14 (14:55)			14563.1	11/14 (15:25)	36521.3	10/14 (6:05)
NO ₂	4.6							178.2	9/29 (8:50)	234.7	9/29 (9:20)

1 - Geometric Mean, 2 - 30-Minute Averaging Time, *Start of time interval of occurrence.

+ Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

** High hydrocarbon readings reflect contaminated manifold.

TABLE II C-5 QUARTERLY SUMMARY (SEPTEMBER '74 - NOVEMBER '74)
(Concentrations in Micrograms per Cubic Meter)

TRAILER NO. 024

Recorded Parameter	Average	Maximum 24-hr. Concentration		Maximum 8-hr. Concentration		Maximum 3-hr. Concentration		Maximum 1-hr. Concentration		Maximum 5-min. Concentration	
		Value	Time	Value	Time*	Value	Time*	Value	Time*	Value	Time*
SO ₂	0.2	12.5	10/23 (2:00)			14.4	10/23 (5:15)	14.8 ²	10/23 (3:50)	15.6	10/23 (2:05)
H ₂ S	0.0							8.3	11/5 (15:55)	12.5	11/5 (16:20)
Particulates +	23.7 ¹	178.0	11/27								
Total Hydrocarbons											
CH ₄											
Non-CH ₄ Hydrocarbons											
O ₃											
NO _x											
NO											
CO											

1 - Geometric Mean, 2 - 30-Minute Averaging Time, *Start of time interval of occurrence.

+ Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-6
AIR QUALITY SUMMARY

(Concentrations in micrograms per cubic meter)

Trailer No. 020 Trailer Location Redd Ranch Period December, 1974

Contaminant	Monthly Average	Maximum		Maximum		Maximum		Maximum		Maximum	
		24 hr. Value	Concentration Time*	8 hr. Value	Concentration Time*	3 hr. Value	Concentration Time*	1 hr. Value	Concentration Time*	5 min. Value	Concentration Time*
SO ₂	1.8	14.4	12/8 (3:00)	-	-	17.2	12/9 (0:05)	17.4	12/8 (21:40)	41.7	12/13 (12:15)
H ₂ S	0.0	-	-	-	-	-	-	2.2	12/8 (7:10)	15.2	12/20 (13:20)
Particulates ¹ **	4.3 ¹	11.0	12/12	-	-	-	-	-	-	-	-
Total Hydrocarbons	1015.7	-	-	-	-	1265.0	12/8 (6:00)	-	-	3232.1	12/24 (2:00)
CH ₄	918.8	-	-	-	-	1219.5	12/8 (6:00)	-	-	3241.8	12/24 (1:40)
Non-CH ₄	97.4	-	-	-	-	179.7	12/19 (6:00)	-	-	2070.9	12/5 (15:55)
O ₃	69.3	-	-	-	-	-	-	117.9	12/12 (11:45)	289.1	12/12 (11:50)
NO _x	7.5	-	-	-	-	-	-	43.1	12/4 (10:00)	174.1	12/31 (10:50)
NO	0.7	-	-	-	-	-	-	16.4	12/9 (7:05)	140.4	12/5 (14:40)
NO ₂	6.8	-	-	-	-	-	-	36.0	12/3 (17:10)	78.6	12/24 (3:25)
CO	676.9	-	-	1451.3	12/15 (6:55)	-	-	1853.7	12/15 (13:30)	4677.7	12/13 (12:15)
1 Geometric mean									*Start of time interval of occurrence		

** Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-7
AIR QUALITY SUMMARY

(Concentrations in micrograms per cubic meter)

Contaminant	Monthly Average	Trailer No. 021		Trailer Location		Rock School		Period		December, 1974	
		24 hr. Value	Maximum Concentration Time*	8 hr. Value	Maximum Concentration Time*	3 hr. Value	Maximum Concentration Time*	1 hr. Value	Maximum Concentration Time*	5 min. Value	Maximum Concentration Time*
SO ₂	1.7	13.6	12/2 (15:00)	-	-	22.6	12/19 (15:30)	25.8	12/19 (15:45)	33.9	12/2 (19:10)
H ₂ S	0.0	-	-	-	-	-	-	4.6	12/7 (8:00)	27.7	12/7 (8:25)
Particulate**	5.4	18.0	12/10	-	-	-	-	-	-	-	-
Total Hydrocarbons	-	-	Not Sampled-	-	-	-	-	-	-	-	-
CH ₄	-	-	Not Sampled-	-	-	-	-	-	-	-	-
Non-CH ₄ Hydrocarbon	-	-	Not Sampled-	-	-	-	-	-	-	-	-
O ₃	-	-	Not Sampled-	-	-	-	-	-	-	-	-
NO _x	-	-	Not Sampled-	-	-	-	-	-	-	-	-
NO	-	-	Not Sampled-	-	-	-	-	-	-	-	-
NO ₂	-	-	Not Sampled-	-	-	-	-	-	-	-	-
CO	-	-	Not Sampled-	-	-	-	-	-	-	-	-
*Start of time interval of occurrence											

** Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-8
AIR QUALITY SUMMARY

(Concentrations in micrograms per cubic meter)

Trailer No. 022 Trailer Location Gerald Oldland Ranch Period December, 1974

Contaminant	Monthly Average	Maximum Concentration		Maximum Concentration		Maximum Concentration		Maximum Concentration		Maximum Concentration	
		24 hr. Value	Time*	8 hr. Value	Time*	3 hr. Value	Time*	1 hr. Value	Time*	5 min. Value	Time*
SO ₂	0.1	2.9	12/19 (20:00)	-	-	20.4	12/20 (0:05)	20.8	12/20 (1:15)	20.8	12/20 (0:10)
H ₂ S	1.2	-	-	-	-	-	-	8.4	12/18 (0:40)	9.7	12/7 (3:15)
Particulate**	4.2	116.0	12/1	-	-	-	-	-	-	-	-
Total Hydrocarbon	-	Not Sampled	-	-	-	-	-	-	-	-	-
CH ₄	-	Not Sampled	-	-	-	-	-	-	-	-	-
Non-CH ₄ Hydrocarbon	-	Not Sampled	-	-	-	-	-	-	-	-	-
O ₃	-	Not Sampled	-	-	-	-	-	-	-	-	-
NO _x	-	Not Sampled	-	-	-	-	-	-	-	-	-
NO	-	Not Sampled	-	-	-	-	-	-	-	-	-
NO ₂	-	Not Sampled	-	-	-	-	-	-	-	-	-
CO	-	Not Sampled	-	-	-	-	-	-	-	-	-

* Start of time interval of occurrence

** Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-9

AIR QUALITY SUMMARY

(Concentrations in micrograms per cubic meter)

Contaminant	Monthly Average	Trailer No. 023		Trailer Location		Met. Tower		Period Dec. 1974	
		Maximum		Maximum		Maximum		Maximum	
		24 hr. Concentration Value	Time	8 hr. Concentration Value	Time*	3 hr. Concentration Value	Time*	1 hr. Concentration Value	Time*
SO ₂	6.4	31.8	12/21 (16:00)	-	-	87.7	12/21 (0:10)	97.9	12/21 (1:55)
H ₂ S	5.2	-	-	-	-	-	-	45.3	12/21 (1:55)
Particulate **	-	22.0	12/4	-	-	-	-	-	-
Total hydrocarbons	21241.2	-	-	-	-	34141.5	12/12 (6:00)	-	-
CH ₄	1053.8	-	-	-	-	1925.3	12/29 (6:00)	-	-
Non-CH ₄ hydrocarbons	20213.6	-	-	-	-	33269.7	12/12 (6:00)	-	-
O ₃	28.0	-	-	-	-	-	-	68.5	12/30 (13:25)
NO _x	-	-	-	-	-	-	-	104.4	12/23 (23:25)
NO	-	-	-	-	-	-	-	93.9	12/24 (1:05)
NO ₂	-	-	-	-	-	-	-	47.0	12/6 (13:10)
CO	2439.3	-	-	5035.2	12/19 (3:55)	-	-	5061.4	12/19 (4:50)
								56.2	12/30 (8:50)
								56.2	12/9 (23:00)
								84.0	12/30 (13:40)
								74.9	12/30 (8:45)
								64530.4	12/20 (17:40)
								3243.1	12/22 (5:40)
								65123.0	12/18 (14:00)
								200.6	12/22 (14:55)

** Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days. * Start of time interval of occurrence

TABLE II C-10

AIR QUALITY SUMMARY

(Concentrations in micrograms per cubic meter)

Contaminant	Monthly Average	Trailer No. 024		Trailer Location Ridge		Period Dec. 1974	
		Maximum 24 hr. Concentration Value	Maximum 8 hr. Concentration Value	Maximum 3 hr. Concentration Value	Maximum 1 hr. Concentration Value	Maximum 5 min. Concentration Value	Maximum Time*
SO ₂	1.7	17.2	12/9(16:00)	-	12/10(6:05)	128.5	12/10(7:10)
H ₂ S	0.1	-	-	-	-	7.7	12/24(1:55)
Particulate**	2.9	8.0	12/5	-	-	-	-
Total hydrocarbons	-	Not Sampled	-	-	-	-	-
CH ₄	-	Not Sampled	-	-	-	-	-
Non-CH ₄ Hydrocarbon	-	Not Sampled	-	-	-	-	-
O ₃	-	Not Sampled	-	-	-	-	-
NO _x	-	Not Sampled	-	-	-	-	-
NO	-	Not Sampled	-	-	-	-	-
NO ₂	-	Not Sampled	-	-	-	-	-
CO	-	Not Sampled	-	-	-	-	-
*Start of time interval of occurrence							

** Certain days are not reflected in the overall average and maxima reported due to incomplete data for those days.

TABLE II C-11

FREQUENCY DISTRIBUTION OF PARTICULATE CONCENTRATIONS

SEPTEMBER 1974 - NOVEMBER 1974 *

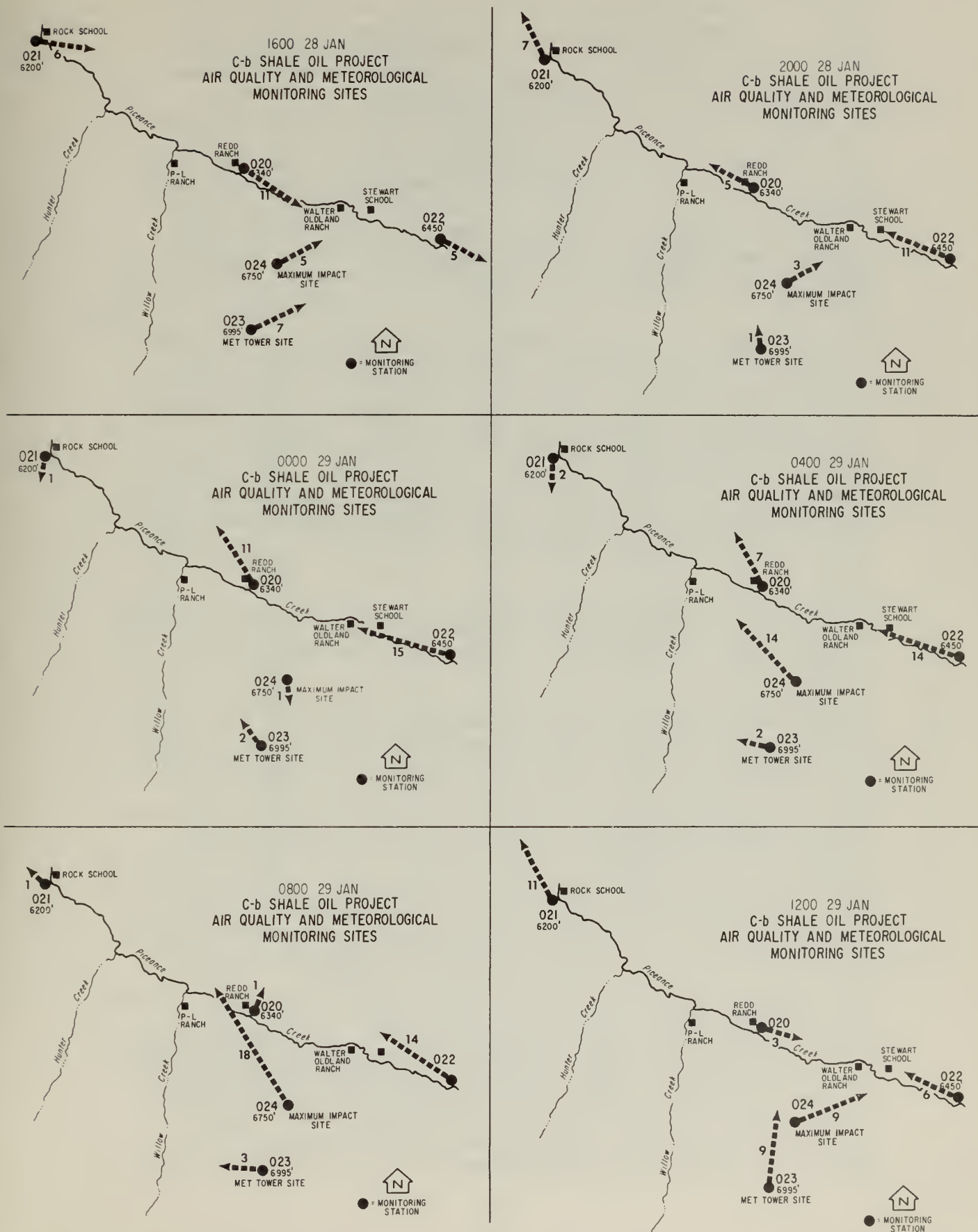
C-b SHALE OIL MONITORING PROJECT

SITE	020	021	022	023	024
CONCENTRATION					
$\mu\text{g}/\text{m}^3$					
>260					
240-260					
220-240					
200-220					
180-200					
160-180					2
140-160			1		0
120-140	1		0		0
100-120	0		0		0
80-100	0		0		0
60- 80	0	1	0		0
40- 60	0	0	0		0
20- 40	0	3	1	4	0
<20	11	14	5	5	2
TOTAL (No. of samples)	12	18	7	9	4
GEOMETRIC MEAN ($\mu\text{g}/\text{m}^3$)	8.2	9.3	11.3	10.5	23.7

* Certain days are not reflected in the composite reported here due to incomplete data for those days.

FIGURE II C-2

DIURNAL VARIATIONS IN WIND VELOCITY



and 022) is northwesterly (i.e. winds from the southeast) and that the downslope direction for both sites (023 and 024) on the plateau is generally northerly (i.e. winds from the south half plane). The winds at 1600 hours on January 28, are up-valley and downslope. By 2000 hours, a near-calm exists at the plateau sites which persists through 0000 hours; winds are downvalley. The downvalley winds at the Oldland Ranch (site 022) persists until the afternoon of the 29th but previously ceased by 0800 at Redd Ranch. A near-calm has existed at the Rock School (site 021) from midnight until late morning of the 29th where an intensive surface temperature inversion has built up from the cool drainage flows of the evening and early morning (see Figure II C-6). By noon the inversion has broken and a complex wind structure which is down-valley (at 021 and 022) at both ends and upvalley in the middle (020) exists.

Another example of diurnal variability in wind direction is shown in Table II C-12 for which the monthly mean wind direction and magnitude are shown for trailer 021 at Rock School for each hour of the day during November. The previous summary report commented that wind systems in mountainous terrain usually combine into upvalley, upslope, upcanyon constrained flow in the daytime and downflow (or "drainage") at night. However, Table II C-12 shows that the flow near Rock School is predominantly down-Piceance-Creek with brief periods of up-Black-Sulfur-Creek and down-Black-Sulfur-Creek in mid-morning and mid-afternoon respectively. Directional changes as high as 69° in a one hour time interval are to be noted.

An intensive, 24-hour field investigation in the area of air quality and meteorology was conducted from 1600 MST, January 28, to 1600 MST on January 29, 1975, hereafter referred to as the "Quick-Look."

Strong surface horizontal temperature gradients were noticed during the "Quick-Look" test period, as evidenced on Figure II C-3. For example, at 0600 on January 29th, temperatures of -26°F , -7°F , and -8°F were recorded at the Rock School, Redd Ranch and the Oldland Ranch sites respectively in Piceance Creek (6300 ft. elevation) and $+11^{\circ}\text{F}$ at the meteorological tower site (6980 ft.). This horizontal surface temperature gradient existed during the presence of an extremely strong inversion. The strongest vertical temperature gradient (i.e. the inversion) occurs at Rock School where the canyon walls are steepest and drainage effects are strongest. At this same time period (actually 0912 on February 2), a constant altitude flight at 7200 ft. MSL was made from directly over Rock School to the C-b tower site indicating no horizontal temperature gradient at that elevation even though one existed in the valley. Thus the inversion was really limited in vertical extent to only over the valley region and did not extend over plateaus. An additional flight was made at 0810 MST on February 9, when no surface inversion existed, up Piceance Creek from Rock School to the Oldland Ranch at a near-surface altitude of 6400 ft. MSL indicating less than 1°F horizontal gradient. Thus the conclusion of this complex pattern is that large horizontal gradients are confined to the valleys and exist only in the presence of a near-surface inversion;

TABLE II C-12

REPRESENTATIVE VARIABILITY IN WIND DIRECTION

Monthly Mean Values
for November, 1974

Trailer 021
(@ Rock School in Piceance Creek)

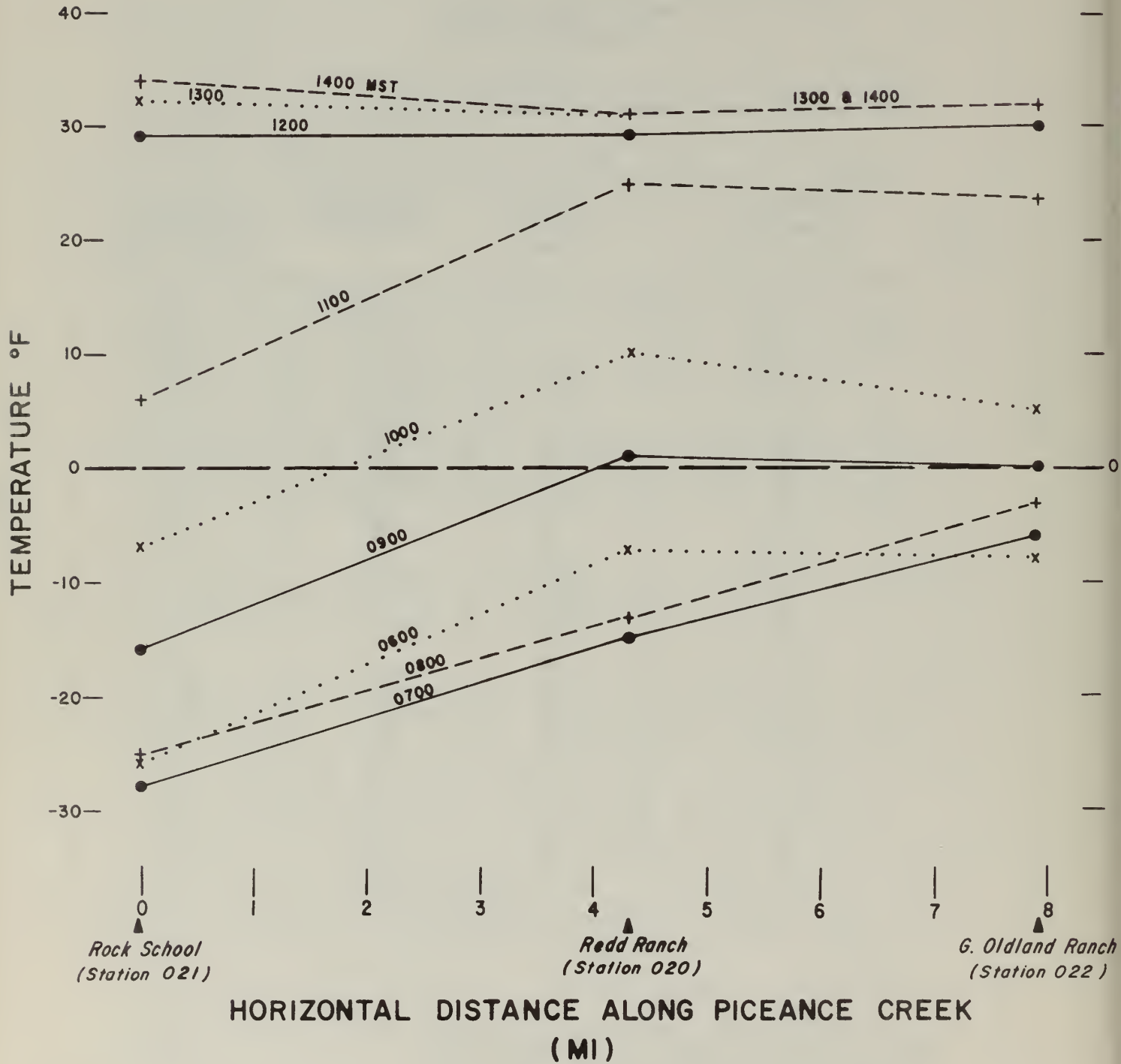
Time (MST)	Monthly Mean Wind Direction (Deg.)	Change in Dir. in One Hr.	General Direction *	Monthly Mean Wind Speed (MPH)
1	124	5	DP	2
2	129	1	DP	2
3	130	-13	DP	2
4	117	+3	DP	2
5	120	-11	DP	2
6	109	+6	DP	2
7	115	-17	DP	2
8	98	-42	~DP	2
9	56	+6	US	2
10	62	+2	US	3
11	64	+69	US	4
12	143	-18	~DP	5
13	125	+68	DP	5
14	193	-32	~DS	5
15	161	+40	~DS	5
16	201	-26	~DS	5
17	175	-62		4
18	113	+9	DP	4
19	122	+3	DP	4
20	125	+9	DP	4
21	134	+4	DP	3
22	138	-5	DP	3
23	133	-9	DP	3
24	124	0	DP	3
1	124		DP	2

*As measured clockwise from the north:

Down Piceance (DP) Direction = $122^{\circ} + 15^{\circ}$
 Up Piceance (UP) Direction = $302^{\circ} + 15^{\circ}$
 Down Black Sulfur (DS) Direction = $230^{\circ} + 15^{\circ}$
 Up Black Sulfur (US) Direction = $50^{\circ} + 15^{\circ}$

Fig. II C-3

HORIZONTAL AIR TEMPERATURE VARIATIONS IN PICEANCE VALLEY 29 JANUARY 1975



when the inversion dissipates, the horizontal gradient dissipates as well.

II C-2 Low Altitude Meteorology

The complex near-surface wind patterns vary with elevation above the surface. To assess this vertical variation, a 200 foot meteorological tower has been installed at the site indicated on Figure II C-1 on page 54.

Low altitude meteorological tower data are obtained at 8', 30', and 100' and 200' for wind direction and speed, relative humidity, and temperature. Barometric pressure and daytime solar radiation are obtained at ground level. Temperature differences are obtained between the 30 feet and 100 feet levels and between the 30 feet and 200 feet levels as part of an integrated approach toward determination of atmospheric stability.

Basic data include diurnal variations (hourly averages) at the four elevations for wind speed, wind direction (as a vector average), relative humidity and temperature. In addition, diurnal temperature differences between 30 feet and 100 feet and between 30 feet and 200 feet are recorded. Daily average values, daily maximum five-minute sliding averages and the time of occurrence and monthly averages are computed for wind speed, wind direction, relative humidity and temperature at each of the four elevations.

Wind roses depicting the frequency of direction from which the wind flows for September, October, November and for the quarter are presented on Figure II C-4. Whereas the directions for September were variable, the dominant direction for the remaining month and for the quarter was southerly for this 100-foot level on the meteorological tower. Both diurnal and elevational effects at the tower on wind vectors are depicted on Figure II C-5 for the "Quick-Look" investigation of January 28 and 29, 1975; this Figure shows that at:

1800 MST a SW wind (3 MPH) @ 8' veers to W (12 MPH) @ 200'
0000 MST a SE wind (2 MPH) @ 8' veers to SSW (3 MPH) @ 200'
0600 MST a ESE wind (2 MPH) @ 8' veers to SE (11 MPH) @ 200'
1200 MST a S wind (9 MPH) @ 8' veers to SSW (17 MPH) @ 200'

III C-3 Upper Air Studies

The purpose of the upper air studies is to obtain wind and temperature vertical profiles from altitudes above the meteorological tower to approximately 6,000 feet above the surface. Furthermore, from knowledge of the changes in the variation in temperature with increasing altitude (called the lapse rate), insights into atmospheric stability are obtained.

Fig. II C-4

WIND ROSES AT THE METEOROLOGICAL TOWER (100')

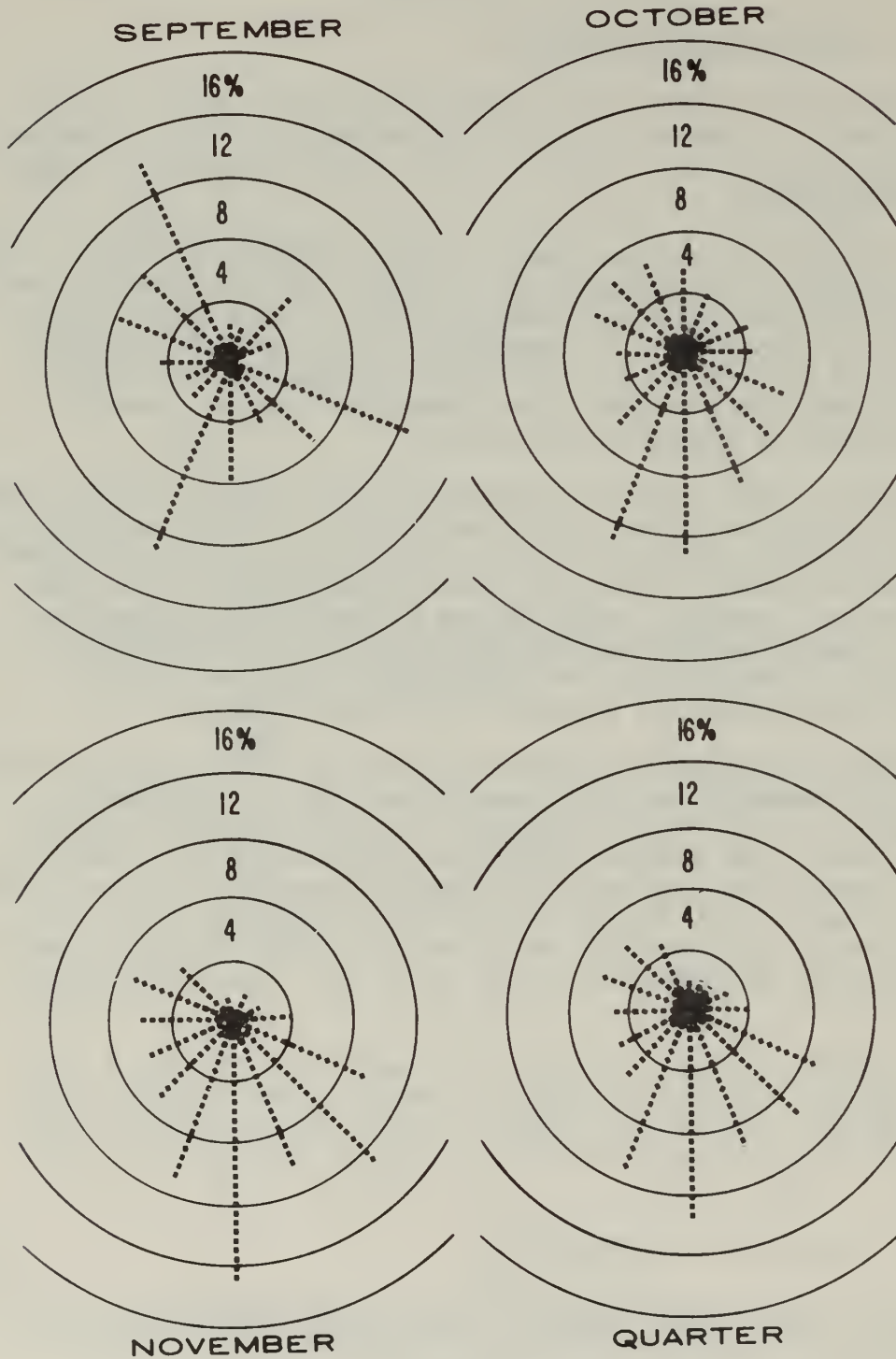
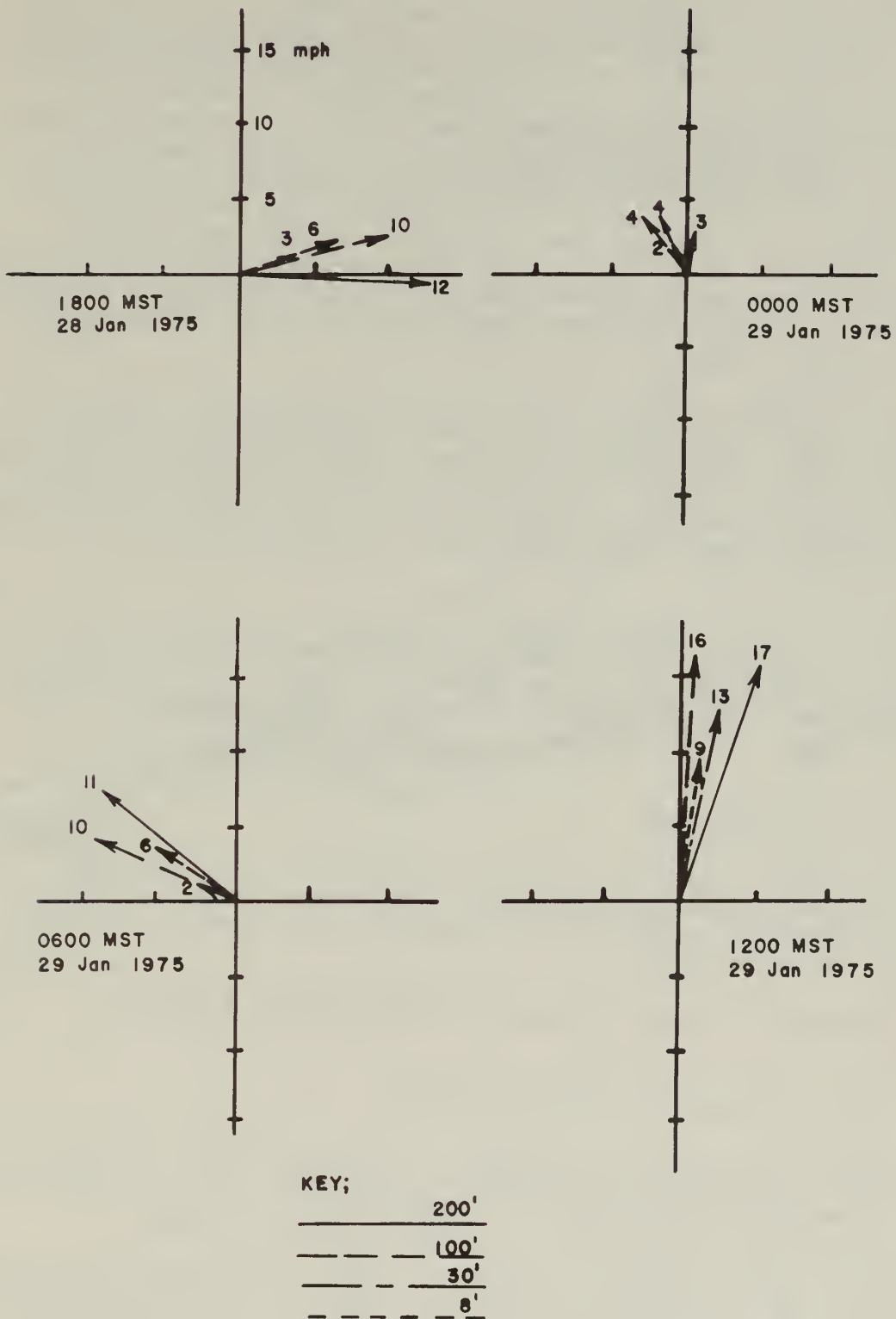


FIGURE II C-5

VARIATION OF WIND VELOCITY WITH HEIGHT ON THE
METEOROLOGICAL TOWER



There are no requirements in the Oil Shale Lease Environmental Stipulations for upper air studies. They are required in Conditions for Approval from the Area Oil Shale Supervisor. Two winds-aloft and temperature profiles per day to altitudes of 6,000 feet above the Tract (equivalent to 13,000 feet elevation (MSL)) are required for a minimum of 15 days per quarter. Data for this reporting period were obtained by E. G. & G. consultants for the wind and temperature profiles during the 15-day period from January 20 to February 9. Winds aloft were obtained from pibal releases at the meteorological tower; temperatures aloft were obtained via an instrumented aircraft. A representative example of four temperature soundings on January 29, 1975, is given in Figure II C-6; the presence of a strong inversion layer from the surface to 7,400 feet (MSL) at 0525 hours is to be noted. Comparisons of temperature profiles with the C-a Tract and with Grand Junction (GJT) are presented in Quarterly Report #2. A representative sample for the nominal 0800 sounding on the same date is given in Figure II C-7.

In addition to the above instrumentation, an acoustic sounder was installed at the meteorological tower location by Marlatt and Associates, consultants, on December 7, 1974, and became operational as of January 2, 1975. It is used to further assist in assessing atmospheric stability by determination of the height and time-extent of unstable layers and stable layers, including inversions on a continuous basis.

Thus far, early morning surface inversions have occurred in the valley for 11 days during the fall 12-day sampling period, and for 9 days during the winter 15-day test period. These inversions dissipate in essentially all cases prior to the nominal 1100 MST sounding.

II C-4 Visibility

There are no visibility baseline requirements in the Oil Shale Lease Environmental Stipulations; site visibility measurements are, however, required in the Conditions for Approval by the Area Oil Shale Supervisor.

*DA-m
Original
Approved* A proposal for these studies is currently being prepared.

II C-5 Atmospheric Diffusion Studies

There are no baseline requirements in the Oil Shale Lease Environmental Stipulations for atmospheric diffusion studies. Conditions for Approval from the Area Oil Shale Supervisor require ground level concentration estimates for 24-hour and 3-hour averages.

These studies will be initiated at a future date when stack emission parameters become available. However, atmospheric stability classifications are a requisite of diffusion models. Toward this end,

FIG II C-6
TEMPERATURE PROFILE

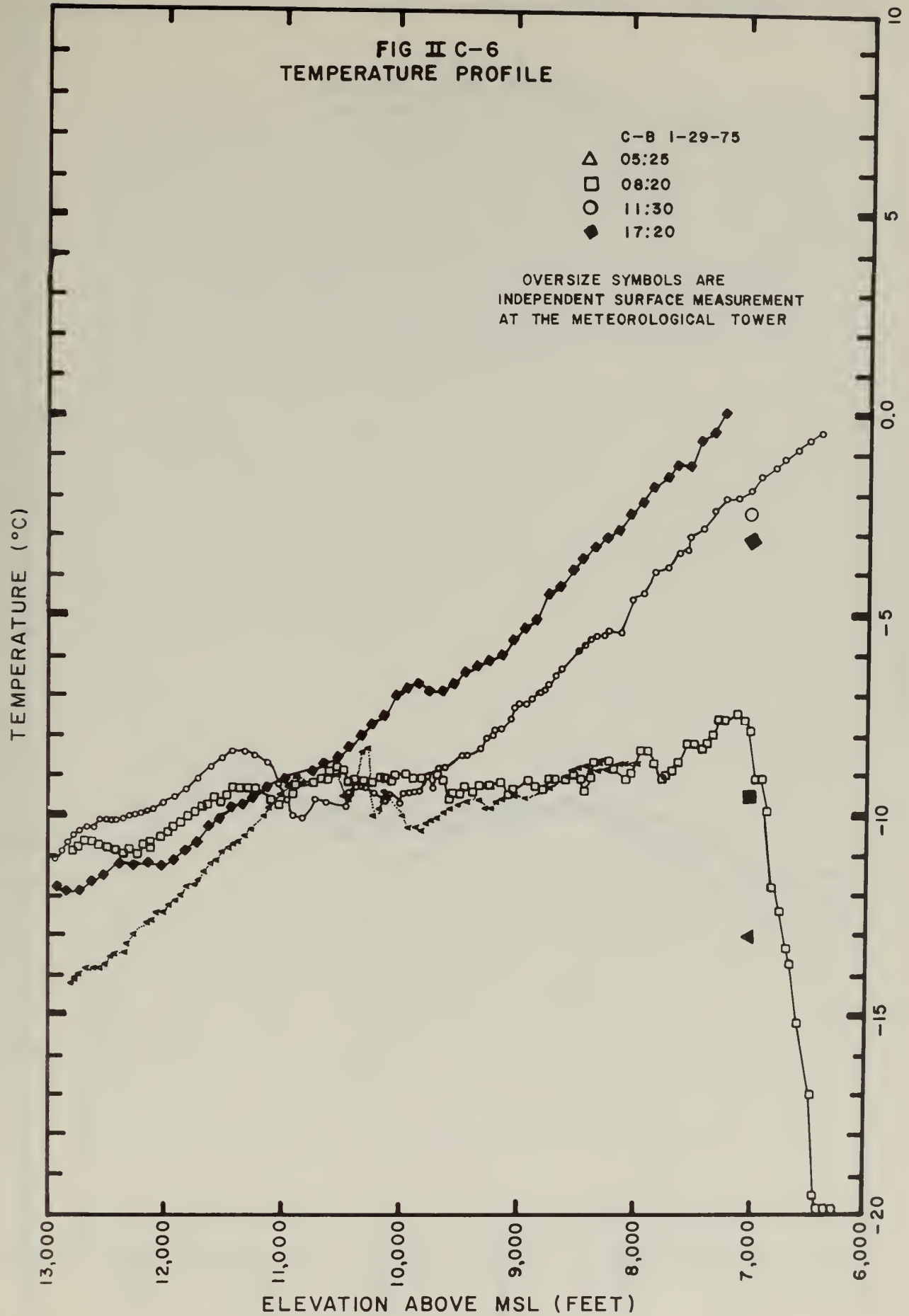
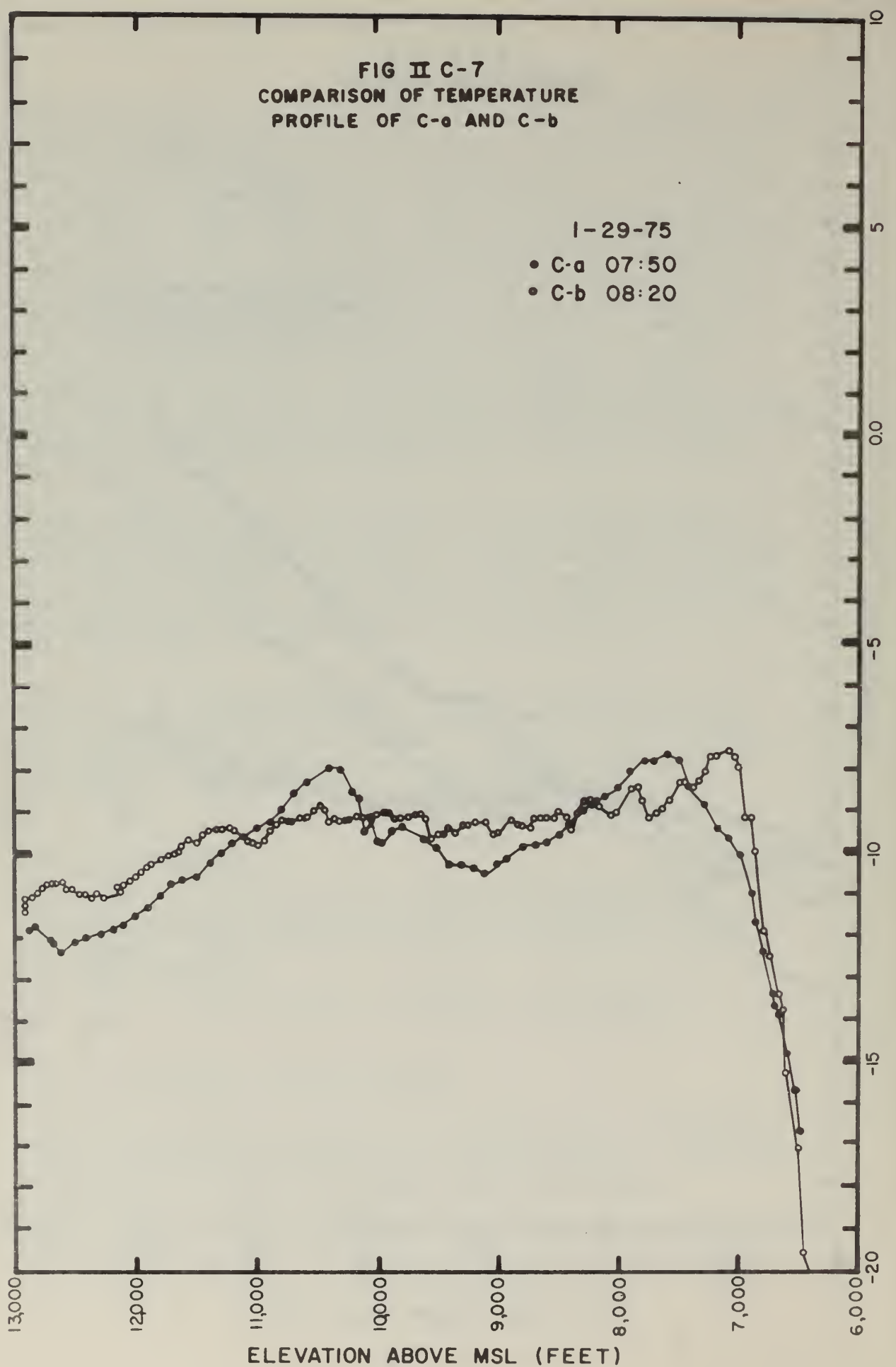


FIG II C-7
COMPARISON OF TEMPERATURE
PROFILE OF C-a AND C-b

1-29-75

- C-a 07:50
- C-b 08:20

TEMPERATURE (°C)



stability was estimated by the following seven techniques during the "Quick-Look" test of January 28 and 29: Temperature soundings, temperature-altitude increments from the meteorological tower, wind speed, solar radiation index, and standard deviations of both the horizontal and vertical components of wind direction. Regarding the slopes of the temperature vs. altitude soundings as the reference technique for stability determination results of this on-going study are presented on Table II C-13 indicating the degree of agreement on stability class from all the techniques. Exact agreement was obtained utilizing the standard deviation of the vertical component of wind direction at the 100-foot level on the meteorological tower for an averaging time of 30 seconds.

TABLE II C-13

ATMOSPHERIC STABILITY* ASSESSMENT - COMPARISON OF RESULTS

TIME OF DAY** SOUNDING (MST)	TEMP. TOWER TEMP. INCREMENTS	WIND SPEED	SOLAR RADIATION INDEX	σ_{θ} (100' BIVANE @ 5 MIN.)	σ_{ϕ} (100' BIVANE @ 30 SEC.)	ACOUSTIC SOUNDER
0525	E	E	D	E	E	INVERSION BELOW TRACT
0820	E	D	D	D	E	STABLE LAYER @ 1200'
1130	D	D	D	C	D	- - -
1720	D	E	D	C	D	- - -

* THESE ARE PASQUILL-GIFFORD STABILITY CLASSES AS REPORTED IN SLADE, DAVID H. (1968): METEOROLOGY AND ATOMIC ENERGY.

** ON JANUARY 29, 1975.

II D BIOLOGY

The biological studies in this quarter are discussed in the following sections:

II D-1 Terrestrial Wildlife Studies

Big Game, Medium-Size Mammals, Small Mammals,
and Birds

II D-2 Aquatic Studies

Fish, Benthos, Periphyton, and Water Quality

II D-3 Terrestrial Vegetation Studies

Floristic Studies

II D-4 Dendrochronology and Dendroclimatology

II D-5 Soils and Soils Productivity Assessment

II D-1 Terrestrial Wildlife Studies

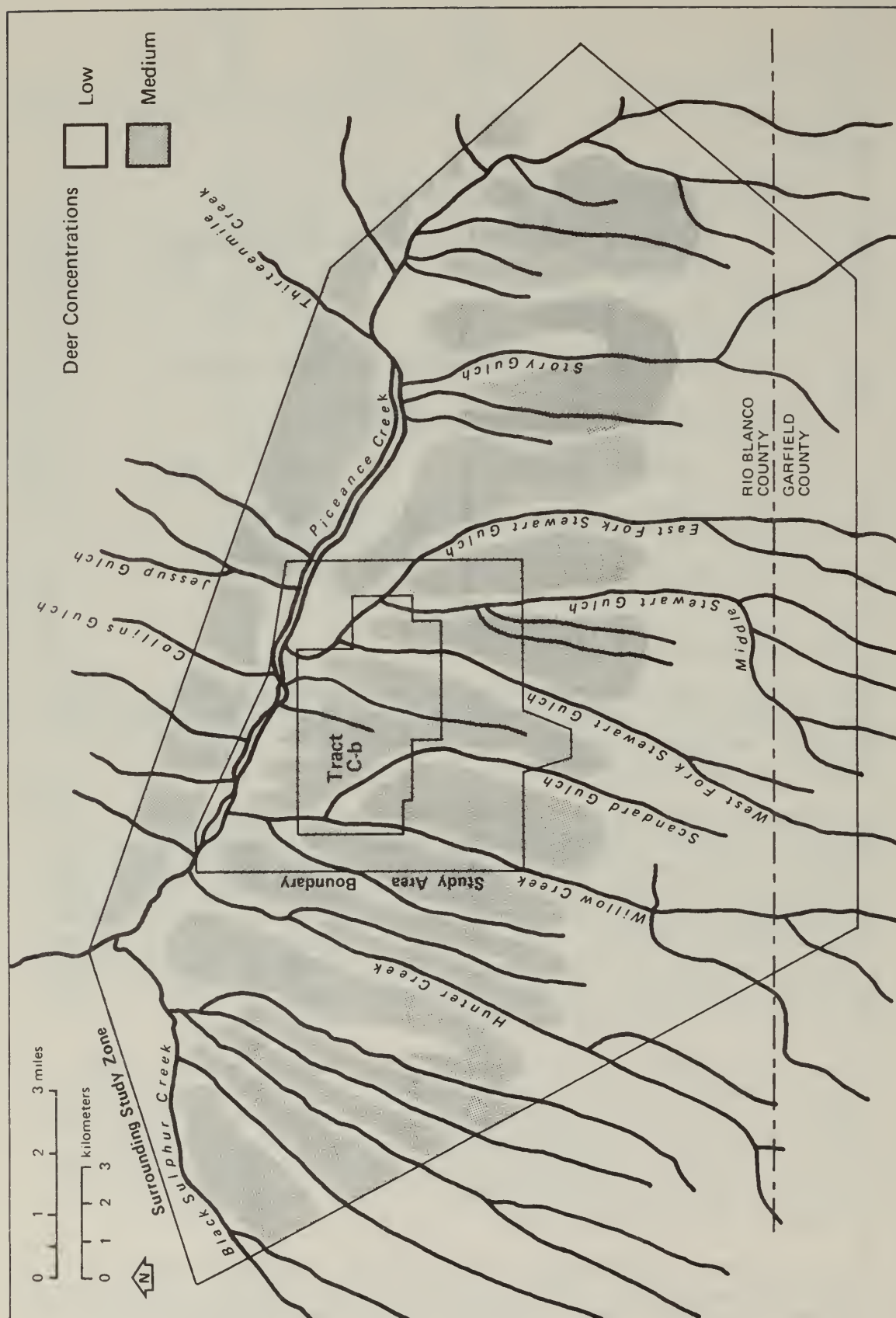
The wildlife program during this quarter included studies of big game, medium-sized mammals, small mammals, and birds. Study areas for these animal groups have been designated and represented on figures in Quarterly Report #1.

The importance of Tract C-b to big game from November 1974 to February 1975 was evaluated through monthly air reconnaissance flights, track counts, and evening road counts. The reconnaissance flights included approximate abundance ranking of deer tracks and were conducted in the area marked on Figures II D-1 and II D-2 as "Surrounding Study Zone". The actual track counts were made along transects within the "Study Area Boundary" shown on the figures. The term "road counts" is self-explanatory, and the roads are not depicted on these particular figures.

In the early fall the deer were utilizing the hay meadows along Piceance and Willow Creeks quite heavily. In December and January, however, the deer had largely abandoned the meadows and were found widely dispersed throughout the pinyon-juniper woodland (Figure II D-1). Browsing occurred mainly in the chained areas and in the woodland. There was little evidence of feeding in the valleys or on grassy south-facing slopes.

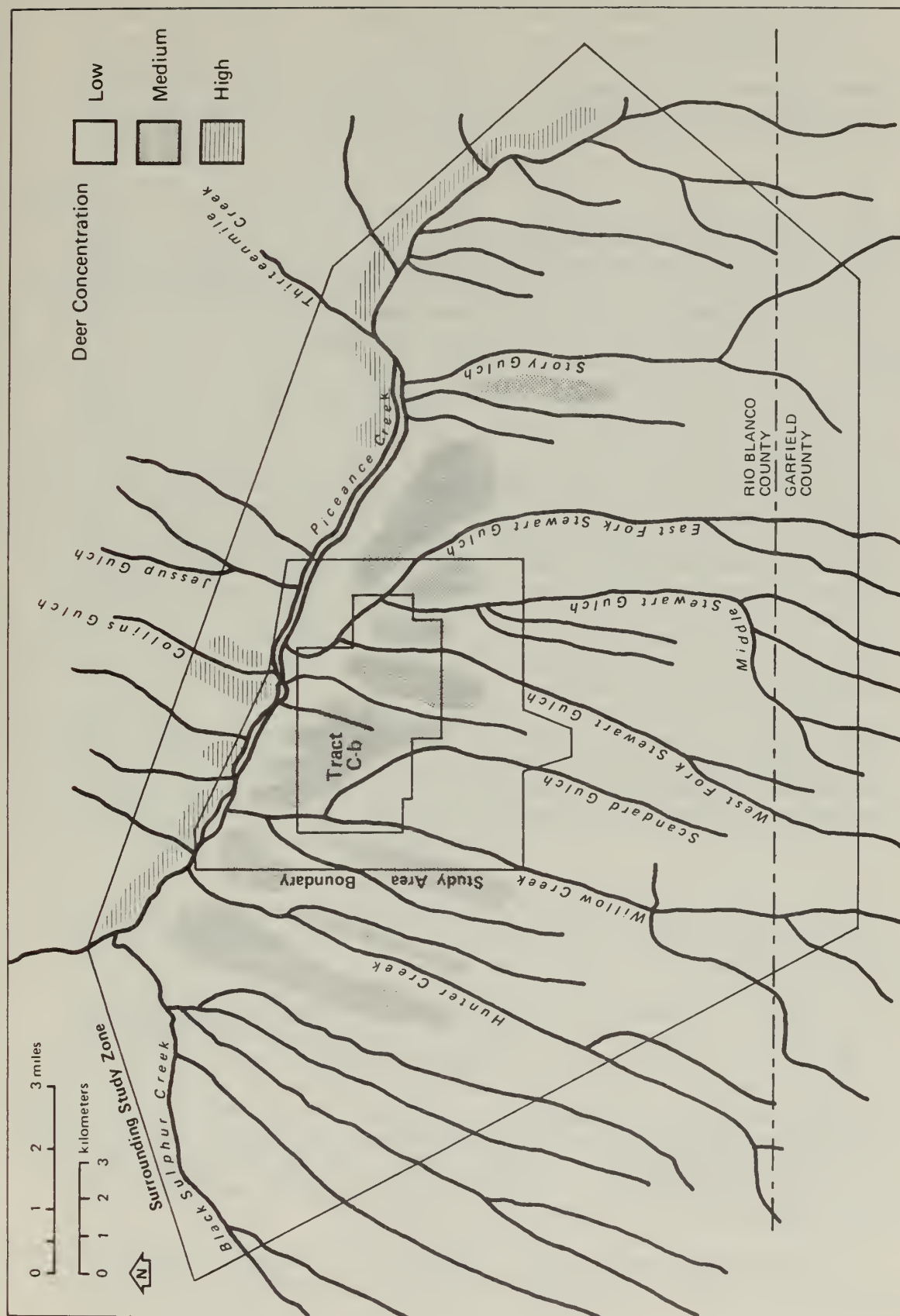
During February, deer began to utilize the south-facing slopes, while they appeared in fewer numbers and were more localized in the pinyon-juniper (Figure II D-2). The shift in habitat usage is probably related to snow conditions, particularly the freeze-thaw cycles which cause drifts to become crusted. Movement of the deer is inhibited by these conditions, and access to food is difficult where snow has

FIGURE II D-1



DISTRIBUTION OF DEER DURING DECEMBER 1974 AND JANUARY 1975

FIGURE 11 D-2



DISTRIBUTION OF DEER DURING LATE FEBRUARY 1975

accumulated. The south-facing slopes, on the other hand, are free of snow and consequently are heavily utilized. January observations show that deer preferred mountain mahogany, serviceberry, and bitterbrush, in that order.

Many medium-sized mammals are inactive during winter, but track counts were used to monitor the active ones. Very few species were noted in the track quadrats this winter, and the frequencies were generally low. Deer tracks were the most abundant in the transects, with cottontail and jackrabbit tracks next in number. (Even though deer are considered big game, their tracks were counted in the medium-sized mammal transects whenever they were found.) The low numbers may indicate a cyclic low in rabbit and hare populations. In many areas of the mountain shrub community, however, tracks and browsing evidence of the jackrabbit were abundant. The shrubs utilized were snowberry, Gambel's oak, and mountain mahogany.

Of the 12 small mammal species identified during the first quarter, only 2 were observed this winter. These included the deer mouse (Peromyscus maniculatus) and the montane vole (Microtus montanus). Most small mammals hibernate or become inactive for extended periods in winter. These include the chipmunks, ground squirrels, and pocket mice. Others, such as the wood rats, store food and reduce their daily activity. Satellite grids were activated to assess the relative activity and abundance of these small mammals. The deer mouse was the more abundant of the species observed. Voles burrow under the snow, and their activity and abundance as revealed in trap results may not be representative of their winter population. In December, before snow covered the valley floors, the voles were very active and abundant above the ground.

The avifauna census conducted in January provided absolute densities of songbirds, relative abundance of all birds and waterfowl, and additional raptor nest locations. Of the 57 species recorded on the transects during fall, only 24 were found in the winter census. An additional 12 species were encountered for the first time.

Twenty wintering bird species were observed on the Tract. The six most abundant species were the horned lark, American robin, gray-crowned rosy finch, black rosy finch, brown-capped finch, and the tree sparrow.

The pinyon jay, mountain chickadee, red-breasted nuthatch, and Townsend's solitaire were typical of the pinyon-juniper woodland. The Piceance Creek area was dominated by horned larks and American robins. Mountain chickadees, dark-eyed juncos, and gray-headed juncos were distributed throughout the mountain brush community. The mixed rabbitbrush-sagebrush area of the West Fork of Stewart Gulch accounted for the American robin, northern shrike, and the tree sparrow. Mallard, green-winged teal, American widgeon, common goldeneye, and bufflehead were the dominant waterfowl.

The rough-legged hawk was the most abundant raptorial bird encountered. The golden eagle, American kestrel, great horned owl, and snowy owl

were also observed, and one observation was made of a prairie falcon off Tract C-b near Piceance Creek between Sorghum and Cottonwood Gulches (the falcon is a nationally threatened species). Additional raptor nests were located this quarter, and pellets and castings were collected for laboratory analysis of prey species.

II D-2 Aquatic Studies

The aquatic studies for this quarter included fish, benthos, periphyton and water quality. The station originally designated as P-4 has been relocated due to similarity in data collected at stations P-3 and P-5; P-5A was added to provide a station on a stretch of stream below a waterfall, a habitat of narrow distribution not represented in the other Piceance Creek stations. Locations of the other sampling stations are shown on page 65 of Summary Report #1.

Fish

Fish collected during January represented the same species collected on previous surveys. The mountain suckers were the most abundant fish, with brook trout second. Mountain suckers were captured in Piceance Creek, Willow Creek, and Stewart Creek, while brook trout were concentrated mainly in Stewart Creek and the channel that drains lower Stewart Lake.

Length-weight tables (Tables II D-1, II D-2, and II D-3) of captured fish were prepared to examine the relative structure of the fish populations. Figure II D-3 illustrates length-weight frequency distribution of brook trout. Most suckers were in the length range of 120-160 mm and probably represent the dominant year class in the population. Mean weights for the dominant year class for suckers range from 16 to 50 gm. Few brook trout were collected in September or November, but January captures show that the dominant year class is in the size range 110-140 mm.

In terms of fish species types, most stations along Piceance Creek are similar (Table II D-4). The White River stations, however, are not similar in species to the others. This is to be expected because the White River has a different environment (river) than that of the Piceance (small stream).

Benthos

The term "benthos" is used to designate the group of organisms that live on or in the bottom of bodies of water. Benthic macroinvertebrate samples in the study area to date have yielded annelids, arthropods, and molluscs. The arthropods, especially insects, were the most numerous. Tables II D-5, II D-6, II D-7, and II D-8 show the seasonal and station differences noted in numbers of benthic individuals and species collected. Benthic samples during this quarter were analyzed for number of individuals, number of species, biomass, species diversity, and for similarities between samples and between stations.

TABLE II D-1

MEAN LENGTHS AND WEIGHTS OF FISH CAPTURED DURING SEPTEMBER 1974

Station	Species*	Number Collected	Mean Length (mm)	Range (mm)	Mean Weight (mg)	Range (mm)
P-1	<u>C. platyrhynchus</u> <u>R. osculus</u>	104 30	136.5 85.0	(85-190) (69-104)	23.6 4.4	(6-72) (2-8)
P-2	<u>C. platyrhynchus</u>	24	158.1	(118-208)	48.4	(20-94)
P-3	<u>C. platyrhynchus</u>	2	194.5	(172-217)	90.0	(62-118)
P-4	<u>C. platyrhynchus</u>	1	136.0	-	30.0	-
P-5	<u>C. platyrhynchus</u>	3	141.0	(140-143)	33.3	(28-36)
P-6	<u>C. platyrhynchus</u> <u>R. osculus</u>	18 6	100.5 73.8	(71-175) (52-92)	12.7 4.8	(4-28) (1-10)
P-7	<u>C. platyrhynchus</u> <u>R. osculus</u>	2 8	165.0 73.5	(155-175) (57-91)	48.0 7.0	(36-60) 4-12)
W-3	<u>C. platyrhynchus</u> <u>R. osculus</u> <u>S. fontinalis</u>	1 1 1	114.0 81.0 16.0	- - -	14.0 6.0 103.0	- - -
SL-2	<u>S. fontinalis</u>	36	96.4	(70-255)	19.1	(1-170)

*Species Legend:

Catostomus platyrhynchus (mountain sucker)Rhinichthys osculus (speckled dace)Salvelinus fontinalis (brook trout)

TABLE II D-2

MEAN LENGTHS AND WEIGHTS OF FISH CAPTURED DURING NOVEMBER 1974

Station	Species*	Number Collected	Mean Length (mm)	Range (mm)	Mean Weight (mg)	Range (mg)
P-1	<u>C. platyrhynchus</u>	44	127.9	(91-170)	20.05	(4-44)
	<u>R. osculus</u>	4	83.7	(80-88)	3.3	(2-4)
	<u>S. fontinalis</u>	1	142.0	-	22.0	-
	<u>S. trutta</u>	1	322.0	-	366.0	-
P-2	<u>C. platyrhynchus</u>	14	169.3	(131-205)	60.0	(22-96)
P-3	<u>C. platyrhynchus</u>	48	144.1	(81-200)	36.3	(8-92)
	<u>R. osculus</u>	2	67.5	(64-71)	6.0	(6-6)
P-4	<u>R. osculus</u>	2	63.0	(61-65)	3.0	(2-4)
P-5	<u>C. platyrhynchus</u>	7	124.7	(81-150)	14.3	(2-36)
P-6	None collected	-	-	-	-	-
P-7	None collected	-	-	-	-	-
W-3	<u>C. platyrhynchus</u>	1	180.0	-	56.0	-
	<u>S. fontinalis</u>	2	237.0	(130-344)	212.0	(24-400)
WR-1	<u>C. latipinnis</u>	1	450.0	-	884.0	-
	<u>R. osculus</u>	1	78.0	-	6.0	-
	<u>C. bairdi</u>	1	115.	-	14.0	-
SL-2	<u>S. fontinalis</u>	15	130.3	(73-246)	24.73	(2-146)

*Species Legend:

Catostomus platyrhynchus (mountain sucker)
Catostomus latipinnis (flannel mouth sucker)
Rhinichthys osculus (speckled dace)
Cottus bairdi (mottled sculpin)
Salmo trutta (brown trout)
Salvelinus fontinalis (brook trout)

TABLE II D-3

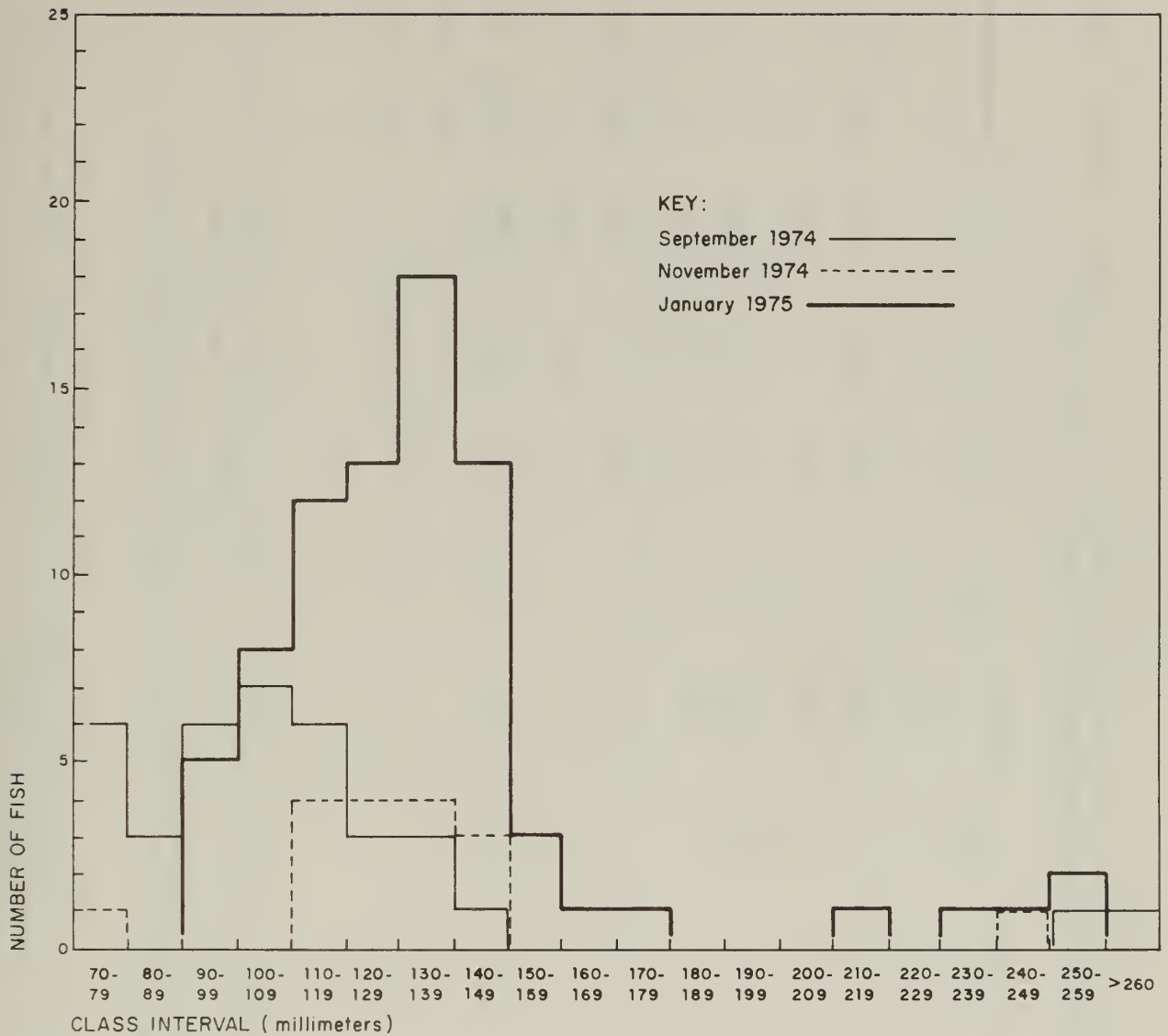
MEAN LENGTHS AND WEIGHTS OF FISH CAPTURED DURING JANUARY 1975

Station	Species *	No. Collected	Mean Length (mm)	Range	Mean Weight (gms.)	Range
P-2	<u>C. platyrhynchus</u>	71	154.5	(100-212)	39.0	(8-102)
	<u>S. fontinalis</u>	1	135.0	---	18	---
W-3	<u>C. platyrhynchus</u>	6	111.3	(88-140)	12.7	(4-22)
S-2	<u>C. platyrhynchus</u>	11	130.7	(102-157)	20.4	(8-34)
	<u>R. osculus</u>	15	90.8	(77-124)	6.5	(4-18)
	<u>S. fontinalis</u>	36	127.4	(101-150)	14.6	(6-28)
SL-2	<u>R. osculus</u>	2	85.0	(82-88)	4	---
	<u>S. gairdneri</u>	1	202.0	---	86.0	---
	<u>S. fontinalis</u>	42	149.4	(92-293)	36.3	(6-202)

* Species Legend:

Catostomus platyrhynchus (mountain sucker)Rhinichthys osculus (speckled dace)Salmo gairdneri (rainbow trout)Salvelinus fontinalis (brook trout)

FIGURE II D-3



LENGTH-FREQUENCY DISTRIBUTION OF BROOK TROUT
CAPTURED IN THE PICEANCE BASIN OVER THREE
SAMPLING PERIODS: SEPTEMBER AND NOVEMBER 1974
AND JANUARY 1975

TABLE II D-4

SOERENSEN'S INDEX OF SIMILARITY (K) OF SPECIES OF FISH BETWEEN STATIONS* (Number of species at a station summed over all samples at the station.)

STATIONS	P-1	P-2	P-3	P-5	P-5A	P-6	P-7	W-3	S-2	L.S.L.	WR-1	WR-2
P-1	X	0.67	0.67	0.67	0.33	0.67	0.67	0.86	0.86	0.57	0.0	0.0
P-2		X	0.50	0.50	0.50	0.50	0.50	0.80	0.80	0.40	0.0	0.0
P-3			X	1.0	0.50	1.0	1.0	0.80	0.80	0.40	0.0	0.0
P-5				X	0.50	1.0	1.0	0.80	0.80	0.40	0.0	0.0
P-5A					X	0.50	0.50	0.40	0.40	0.40	0.0	0.0
P-6						X	1.0	0.80	0.80	0.40	0.0	0.0
P-7							X	0.80	0.80	0.40	0.0	0.0
W-3								X	1.0	0.67	0.0	0.0
S-2									X	0.67	0.0	0.0
SL-2										X	0.0	0.0
WR-1											X	0.75
WR-2												X

*K indicates the relative degree of similarity between two samples with respect to a particular parameter. A value of 1.0 indicates the samples are identical while a zero value indicates no similarity. 0.650 is considered the break point below which the pairs are not considered similar and above which they are considered similar.

TABLE II D-5

NUMBER OF BENTHIC INDIVIDUALS AND SPECIES AT EACH BIOLOGICAL SAMPLING STATION FOR
PICEANCE CREEK DURING NOVEMBER AND DECEMBER 1974 AND JANUARY 1975

	Station																	
	P-1			P-2			P-3			P-4			P-5			P-5A		
	A*	B	C*	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
NOVEMBER																		
<u>Replicate Totals</u>																		
Number of Individuals	203	94	202	82	73	15	179	107	27	24	7	13	63	229	44	330	263	21
Number of Species	12	8	10	5	6	6	13	14	9	5	5	4	10	8	7	10	8	4
<u>Station Totals</u>																		
Number of Individuals	499			170			313			44			336			115		21
Number of Species	12			7			18			10			11			4		4
DECEMBER																		
<u>Replicate Totals</u>																		
Number of Individuals	29	26	89	197	77	150	27	130	152				89	57	15	53	25	32
Number of Species	3	2	3	11	7	4	5	11	11				4	7	4	6	2	6
<u>Station Totals</u>																		
Number of Individuals	144			424			309			161			110			69		12
Number of Species	4			11			15			8			8			8		5
JANUARY																		
<u>Replicate Totals</u>																		
Number of Individuals	36	69	117	52	37	38	53	175	165				126	52	49	7	4	5
Number of Species	4	5	4	6	5	5	4	7	7				7	6	5	3	2	2
<u>Station Totals</u>																		
Number of Individuals	222			127			393			227			16			69		53
Number of Species	6			9			7			10			3			6		4

Note Station P-4 was relocated to P-5A in December 1974.

* Replicate samples taken for purpose of statistical analyses.

TABLE II D-6

NUMBER OF BENTHIC INDIVIDUALS AND SPECIES AT EACH BIOLOGICAL SAMPLING STATION FOR WILLOW CREEK AND LAKES DURING NOVEMBER AND DECEMBER 1974 AND JANUARY 1975

	Station											
	W-1			W-2			W-3			WL-1		
	A*	B*	C*	A	B	C	A	B	C	A	B	C
NOVEMBER												
<u>Replicate Totals</u>												
Number of Individuals	125	106	251	17	122	45	23	116	33	194	--	--
Number of Species	11	8	13	7	13	8	4	13	7	3	--	--
<u>Station Totals</u>												
Number of Individuals	482				184			172		194	220	
Number of Species	15				14			14		3	4	
DECEMBER												
<u>Replicate Totals</u>												
Number of Individuals	42	9	39	19	4	22	21	10	13	47	--	--
Number of Species	12	4	9	8	2	7	3	3	6	4	80	5
<u>Station Totals</u>												
Number of Individuals	90				45			44		47	80	
Number of Species	14				8			7		4	5	
JANUARY												
<u>Replicate Totals</u>												
Number of Individuals	--	--	--	--	--	--	5	19	57	--	--	--
Number of Species	--	--	--	--	--	--	2	7	8	--	--	--
<u>Station Totals</u>												
Number of Individuals	--				--			81		--	--	
Number of Species	--				--			10		--	--	

Note: Missing values unobtainable because of weather conditions.

* Replicate samples taken for purpose of statistical analyses.

TABLE II D-7

NUMBER OF BENTHIC INDIVIDUALS AND SPECIES AT EACH BIOLOGICAL
SAMPLING STATION FOR WHITE RIVER DURING NOVEMBER AND
DECEMBER 1974 AND JANUARY 1975

	Station					
	WR-1			WR-2		
	A*	B*	C*	A	B	C
NOVEMBER						
<u>Replicate Totals</u>						
Number of Individuals	29	51	829	340	961	76
Number of Species	5	11	18	13	16	7
<u>Station Totals</u>						
Number of Individuals	909			1377		
Number of Species	18			19		
DECEMBER						
<u>Replicate Totals</u>						
Number of Individuals	102	64	92	20	50	26
Number of Species	10	8	10	4	8	5
<u>Station Totals</u>						
Number of Individuals	258			96		
Number of Species	14			9		

Note: Weather conditions precluded taking samples in January 1975.

* Replicate samples taken for purpose of statistical analyses.

TABLE II D-8

NUMBER OF BENTHIC INDIVIDUALS AND SPECIES AT EACH BIOLOGICAL SAMPLING STATION FOR
STEWART CREEK AND LAKES DURING NOVEMBER AND DECEMBER 1974 AND JANUARY 1975

	Station											
	S-1			S-2			SL-1			SL-2		
	A*	B*	C*	A	B	C	A	B	C	A	B	C
NOVEMBER												
<u>Replicate Totals</u>												
Number of Individuals	8	13	17	361	46	25	35	--	--	124	--	--
Number of Species	5	2	4	10	10	7	2	--	--	3	--	--
<u>Station Totals</u>												
Number of Individuals	38				432			37		127		
Number of Species	8				17			2		3		
DECEMBER												
<u>Replicate Totals</u>												
Number of Individuals	11	40	12	161	38	150	--	--	--	434	--	--
Number of Species	4	7	2	8	6	7	--	--	--	5	--	--
<u>Station Totals</u>												
Number of Individuals	63				349			--		434		
Number of Species	8				9			--		5		
JANUARY												
<u>Replicate Totals</u>												
Number of Individuals	--	--	--	50	17	37	--	--	--	--	--	--
Number of Species	--	--	--	5	5	5	--	--	--	--	--	--
<u>Station Totals</u>												
Number of Individuals	--				104			--		--		
Number of Species	--				7			--		--		

Note: Missing values unobtainable because of weather conditions.

* Replicate samples taken for purpose of statistical analyses.

Generally, shifts in biomass and species diversity were attributed to seasonal changes. These changes are natural and reflect both quantitative and qualitative changes in the fauna over time. Any significant differences between stations were attributed to differences in habitat. Analysis of sample similarities indicated that many of the stations have roughly the same species composition, and that triplicate samples are generally adequate to describe the bottom fauna. Species diversity indices remained relatively constant over the entire study period and it is concluded that the benthic community has been relatively stable since September, 1974.

Periphyton

The term "periphyton" is used to designate the assemblage of microscopic plants and invertebrates that covers solid substrata in aquatic environments. Stations on Willow Creek and on the White River generally supported the greatest number of genera of periphytic algae. The number of genera did not appear to vary greatly over time for the Piceance Creek stations.

Biomass estimates show that Stewart Creek exhibited the lowest standing crop (Table II D-9). Seasonal changes in biomass were evident; as winter approached, 8 of 12 stations showed a decrease in biomass.

Water Quality

Water samples were analyzed for common minerals and nutrients, dissolved oxygen, pH, specific conductance, coliform counts, and pathogens. Total dissolved solids in the samples taken from Piceance Creek, Stewart Creek, and Willow Creek ranged from 700-1050 ppm. The presence of fecal coliforms and streptococci is shown for Piceance Creek and the White River in Tables II D-10 and II D-11. Since the density ratio of fecal streptococci to fecal coliform is characteristically low for human wastes (on the order of 0.25) and characteristically higher for the wastes of nonhuman warm-blooded animals (generally greater than 1.5 and often much higher), the data in Table II D-10 indicate the fecal contamination to be occurring from animal sources, due probably to the cattle grazing on the meadows paralleling Piceance Creek and other watercourses near Tract C-b. No pathogenic bacteria were identified in the water samples.

II D-3 Terrestrial Vegetation Studies

The vegetation studies on Tract C-b are designed to provide baseline data on various aspects of the plant life. One important feature of the compositional details of vegetation is floristics. Stated simply, floristics is the study of the species in an area, the distribution of those species, and their relative abundance. (This information is basic to the remaining studies of vegetation structure and function.) The primary effort this quarter was the preparation of an annotated flora for Tract C-b and work on the vegetation map.

*function
of veg community*

The annotated flora of those species collected to date presents family, scientific common names, statement of abundance, community affinity or

TABLE II D-9

ESTIMATES OF PERIPHYTON MEAN BIOMASS (gm/m^2) BASED ON THREE REPLICATE SAMPLES
AT EACH STATION FOR SEPTEMBER, OCTOBER AND NOVEMBER 1974

MONTH	STATION											
	P-1	P-2	P-3	P-5	P-6	P-7	W-1	W-3	WR-1	WR-2	S-1	S-2
September												
\bar{X}^a	0.102	0.0767	0.1006	0.1633	0.0368	- -	0.0199	0.0029	0.386	0.0164	0.0018	0.0092
S.D.	0.0161	0.0070	0.0156	0.0119	0.0644	- -	0.0355	0.0003	0.0322	0.0170	0.0018	0.0012
gm/m ²	52.71	39.64	51.99	84.39	19.02	- -	10.28	1.50	19.95	8.48	0.93	4.75
October												
\bar{X}^a	0.0977	0.0203	0.0492	0.0868	0.0005	0.0348	0.0096	0.0055	- -	- -	0.0012	0.0040
S.D.	0.0057	0.0050	0.0033	0.0057	0.0002	0.0046	0.0041	0.0026	- -	- -	0.0002	0.0018
gm/m ²	50.49	10.51	25.43	44.84	0.2756	17.98	4.96	2.84	- -	- -	0.6202	2.07
November												
\bar{X}^a	0.0516	0.0084	0.0471	0.0046	0.0240	0.0161	0.0519	0.0269	0.0112	0.0091	0.0057	0.0029
S.D.	0.0066	0.0024	0.0013	0.0026	0.0093	0.0226	0.0070	0.0098	0.0136	0.0070	0.0032	0.0017
gm/m ²	26.67	4.34	24.34	2.36	12.42	8.30	26.82	13.90	5.79	4.70	2.93	1.50

a: Mean value for three replicate samples at each station. Total weight (grams).

TABLE II D-10

MICROBIOLOGY OF PICEANCE CREEK, STATIONS 1 THROUGH 7, TAKEN IN NOVEMBER AND DECEMBER 1974 AND JANUARY 1975

	Standard Plate Count/ml at 35° C.	Coliform MPN/100 ml	Fecal Coliform ^m MPN/100 ml	Fecal Streptococci MPN/100 ml	Pathogens
<u>Station P-1</u>					
November	280,000	23	4	43	Not Detected
December	170,000	1,100	23	43	" "
* January					
<u>Station P-2</u>					
November	820,000	24,000	<3	23	
December	190,000	280	43	93	
January	20,000	1,100	23	7	
<u>Station P-3</u>					
November	270,000	750	<3	39	Not Detected
December	190,000	750	3	9	" "
January	35,000	460	460	240	" "
<u>**Station P-4</u>					
November	570,000	2,300	9	93	
December					
January					
<u>Station P-5</u>					
November	420,000	2,400	21	150	
December					
January	26,000	93	93	23	
<u>Station P-6</u>					
November					
December	550,000	93	43	4	
January	36,000	93	93	43	

* Stations were frozen over.

** Station P-4 was eliminated in December 1974.

TABLE II D-11

MICROBIOLOGY OF THE WHITE RIVER, STATIONS 1 AND 2, TAKEN IN NOVEMBER AND DECEMBER 1974
AND JANUARY 1975

	Standard Plate Count/ml at 35°C.	Coliform MPN/100 ml	Fecal Coliform MPN/100 ml	Fecal Streptococci MPN/100 ml	Pathogens
<u>Station WR-1</u>					
November	54,000	1,500	240	9	Not Detected
December	6,600	1,500	390	93	" "
January	5,400	75	75	43	" "
<u>Station WR-2</u>					
November	52,000	240	2,100	23	
December	21,000	11,000	460	240	
January	4,000	1,100	93	43	

habitat, life form, and geographical distribution. Table II D-12 gives a Life Fork Spectrum of the 172 species found thus far on-tract. Using Raunkier's classification system for life forms, it is found that the Tract C-b flora is composed mostly of hemicryptophytes (plants having their perennating bud in the soil surface) and phanerophytes (perannating bud at least 0.25 meters above the soil surface). The percentage distribution of different life forms on the Tract suggest a shrubland flora with a high percentage of herbaceous perennials.

Tables II D-13 through II D-15 contain the floristic information developed during this quarter. Table II D-15 is the annotated vascular flora; Table II D-16 (starting on p. 118) alphabetizes these plants by their common names for reference purposes. Tables II D-13 and II D-14 explain abbreviated notations in Table II D-15; Tables II D-13 explains life form abbreviations and Table II D-14 explains geographical distribution notations. Collection and identification of terrestrial non-vascular plants (mosses, lichens, and fungi) will begin in the forthcoming quarter.

II D-4 Dendrochronology and Dendroclimatology

The dendrochronological and dendroclimatological studies on Tract C-b were initiated to (1) produce a master chronology that dates the growth increments of pinyon pine for the Tract, and (2) study the variations in past and present climate and make future climatic projections.

Results and Discussion

During this quarter all trees have been dated by the cross-dating method. Stand chronologies and a master chronology have been constructed. Dated growth increments from the master chronology were measured and a mean width of each annual increment was calculated for each tree.

Mean tree-ring measurements for each tree were converted to standardized indices and then correlated to October through June precipitation values. Those trees that were positively correlated to precipitation were used to make a dendroclimatic analysis. That analysis is being completed and should be available for Quarterly Report #3.

II D-5 Soils Survey and Productivity Assessment

A Soil Productivity Program was undertaken in January, 1975, to meet the need for a bioassay of the soils on Tract C-b to determine their ability to support vegetation. A preliminary soil reconnaissance was conducted in November, 1974 and sites were selected for topsoil sampling. Soil samples were collected in January and transported to California for experimentation. The field work for the Soil Survey Program has been deferred until spring of 1975 because of frozen soils. These studies will determine the physical and chemical characteristics of the various soils found on Tract C-b.

TABLE II D-12

LIFE FORM SPECTRUM OF SPECIES^a ON TRACT C-b

Life Form	Percentage Distribution of Species:	
	Tract C-b	Normal Spectrum ^b
Phanerophytes	18.5	46.0
Chamaephytes	3.5	9.0
Hemicryptophytes	48.2	26.0
Cryptophytes	14.0	6.0
Therophytes	15.1	13.0

^a172 species^bAfter Raunkiaer, 1934

TABLE II D-13

ABBREVIATIONS OF LIFE FORMS OF PLANTS USED
IN DESCRIBING THE FLORA OF TRACT C-b

Ph	- Phanerophytes (perennating bud at least 0.25 m above soil surface)
MM	- Mega-, Mesophanerophytes (>8 m in height)
M	- Microphanerophytes (2-8 m in height)
N	- Nanophanerophytes (0.25-2.0 m in height)
	(suffix "v" with any of the above symbols indicates a vine)
Ch	- Chamaephytes (perennating bud between 0 and 0.25 m above soil surface)
Chp	- passive chamaephytes
Chcp	- cushion plants
H	- Hemicryptophytes (perennating bud in soil surface)
Hp	- Proto-hemicryptophytes without runners (plant leafy throughout)
Hs	- Semirosette without runners (plant with large basal leaves and smaller cauline leaves)
Hr	- Rosette without runners (plant with well-developed basal leaves and no cauline leaves)
Hpr	- Proto-hemicryptophytes with runners
Hsr	- Semirosette with runners
Hrr	- Rosette with runners
	(runner is here used for either hypogeal or epigeal shoot)
Cr	- Cryptophytes (perennating buds covered by soil or water)
G	- Geophytes (perennating buds covered by soil)
Grh	- Rhizome
Gst	- Stem-tuber
Grt	- Root-tuber
Gb	- Bulb
Gr	- Root-bud
Gp	- Root-parasite
HH	- Helo-, hydrophytes (perennating buds covered by water)
Th	- Therophytes (annual plants, perennating buds contained in seed)
S	- Stem succulents (stems enlarged; serve as water storage organ)

SUMMARY OF THE GEOGRAPHICAL DISTRIBUTION OF THE SPECIES
PRESENT IN THE FLORA OF TRACT C-b

Geographical Distribution	Number of Species	Percent of Flora
Circumpolar Distributions		
Arctic circumpolar (Ca)	4	2.3
Arctic-subarctic circumpolar (Cas)	3	1.7
Subarctic circumpolar (Cs)	1	0.6
Subarctic-temperate circumpolar (Cst)	2	1.1
Temperate circumpolar (Ct)	<u>2</u>	<u>1.1</u>
Subtotal	12	6.8
American Distributions		
Arctic American (Aa)	1	0.6
Arctic-subarctic America (Asa)	2	1.1
Subarctic American (As)	14	8.1
Western (Asw)	5	2.9
Subarctic-temperate Amer. (Ast)	6	3.5
Western (Astw)	10	5.8
Temperate American (At)	7	4.0
Western (Atw)	<u>90</u>	<u>52.0</u>
Subtotal	135	78.0
Other Distributions		
European (Ep)	12	7.0
Eurasian (Er)	12	7.0
African (Af)	1	0.6
Tropical American (Ta)	<u>1</u>	<u>0.6</u>
Subtotal	26	15.2
Total	173	

ANNOTATED VASCULAR FLORA FOR TRACT C-b

TREES, SHRUBS, AND VINES

Acer negundo L. Box Elder. (MM). Rare on Tract C-b; moist gulches along intermittent streams (Cottonwood Gulch). Not a rare species in Colorado. At - native. Aceraceae.

Amelanchier alnifolia Nutt. Serviceberry. (M). Common; a dominant species in mixed mountain shrub communities. Asw - native. Rosaceae.

Artemisia tridentata Nutt. Big Sagebrush. (M). Abundant; valley floors, ridges, and slopes over most of the tract. A secondary dominant in mixed mountain shrub communities and a dominant in sagebrush communities. Atw - native. Compositae.

Atriplex canescens (Pursh) Nutt. Four-winged Saltbush. (N). Scattered; dry colluvial slopes. On C-b usually found in Indian ricegrass communities. Atw - native. Chenopodiaceae.

Atriplex confertifolia (Torr. et Fremont) S. Wats. Shadscale. (N). Scattered; dry colluvial slopes and Indian ricegrass communities. Atw - native. Chenopodiaceae.

Ceratoides lanata (Pursh) J.T. Howell. Winter Fat. (N). Frequent; occurs as a secondary dominant with big sagebrush in valley sagebrush communities; uncommon elsewhere. Atw - native. Chenopodiaceae. (Syn. = Eurotia lanata [Pursh] Moquin).

Cercocarpus montanus Raf. Mountain Mahogany. (N). Common; a dominant species in mixed mountain shrub communities and a component of the shrub stratum in pinyon-juniper woodlands. Atw - native. Rosaceae.

Chrysothamnus nauseosus (Pall.) Britt. in Britt. et Brown. Rubber Rabbitbrush. (N). Common; a dominant species in heavily grazed valley communities; a secondary dominant on chained pinyon-juniper sites. Atw - native. Compositae.

Chrysothamnus viscidiflorus (Hook.) Nutt. Little Rabbitbrush. (N). Occasional; ridges and chained pinyon-juniper woodlands. Less common than rubber rabbitbrush. Atw - native. Compositae.

TABLE II D-15
(continued)

Clematis ligusticifolia Nutt. ex T. et G. Western Virgin's-Bower.
(Nv). Scattered; mixed mountain shrub communities and moist
gulches. Atw - native. Ranunculaceae.

Clematis columbiana (Nutt.) T. et G. Blue Clematis. (Nv). Rare;
sheltered gulches and steep forested north-facing slopes. Usually
found on sites occupied by douglas-fir. Atw - native. Ranunculaceae.

Ephedra viridis Coville. Mormon Tea. (M). Scattered; sandstone
outcrops and cliff tops. Atw - native. Ephedraceae.

(?) Eriogonum lonchophyllum T. et G. Wild Buckwheat. (N or Ch). Frequent;
dry colluvial slopes and Indian ricegrass communities. Atw -
native. Polygonaceae.

Eurotia lanata (Pursh) Moquin. See Ceratoides lanata.

Gutierrezia sarothrae (Pursh) Britt. et Rusby. Snakeweed. (Ch).
Frequent; ridgetops and in chained pinyon-juniper woodlands.
Atw - native. Compositae.

Holodiscus dumosus (Nutt.) Heller. Rock Spirea. (N). Very scattered;
heads of draws and gulches, also along sheltered cliff bases on
colluvial deposits. Atw - native. Rosaceae.

Humulus lupulus L. var. neomexicanus A. Nels. et Cockerell. Wild Hops.
(Grh). Scattered; along permanent water courses (Piceance Creek)
and irrigation ditches. Cst - native. Moraceae.

Juniperus osteosperma (Torr.) Little. Utah Juniper. (MM). Abundant;
codominant species with pinyon pine in pinyon-juniper woodlands.
More common than Rocky Mountain Juniper. Atw - native.
Cupressaceae.

Juniperus scopulorum Sarg. Rocky Mountain Juniper. (MM). Relatively
common; occurs as a secondary dominant with pinyon pine and Utah
Juniper in pinyon-juniper woodlands. Atw - native. Cupressaceae.

Mahonia repens (Lindl.) G. Don. Oregon Grape. (Ch). Frequent;
pinyon-juniper woodlands and mixed mountain shrub communities.
Astw - native. Berberidaceae.

TABLE II D-15
(continued)

-
- Opuntia polyacantha Haw. Prickly Pear. (S). Common; throughout the tract in all communities. May reach greater density in overgrazed areas. Atw - native. Cactaceae.
- Pinus edulis Engelm. Pinyon Pine. (MM). Abundant; dominant species in pinyon-juniper woodlands. Atw - native. Pinaceae.
- Populus angustifolia James. Narrow-leaf Cottonwood. (MM). Rare; on Tract C-b restricted to Cottonwood Gulch. Not a rare species in Colorado, but rather one of the most widespread streamside cottonwood species. Atw - native. Salicaceae.
- Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg. Chokecherry. (M). Occasional; mixed mountain shrub communities and moist draws. Ast - native. Rosaceae.
- Pseudotsuga menziesii (Mirbel) Franco. Douglas Fir. (MM). Scattered; restricted to narrow draws with sheltered north- and northeast-facing exposures. The largest tree species in the area. Astw - native. Pinaceae.
- Purshia tridentata (Pursh) DC. Antelope Bitterbrush. (N). Common; mixed mountain shrub communities, shrub layer of pinyon-juniper woodlands, and chained pinyon-juniper woodlands. Atw - native. Rosaceae.
- Quercus gambelii Nutt. Gambel Oak. (M). Frequent; mixed mountain shrub communities and heads of draws. Atw - native. Fagaceae.
- Rhus trilobata Nutt. ex T. et G. Skunkbush. (N). Scattered; mixed mountain shrub communities. Atw - native. Anacardiaceae.
- Ribes aureum Pursh. Golden Currant. (N). Scattered; along intermittent streams, draws, and gulches. Atw - native. Grossulariaceae.
- Ribes cereum Dougl. Currant. (N). Scattered; along intermittent streams, draws, and gulches. Atw - native. Grossulariaceae.
- Ribes inerme Rydb. Smooth Currant. (N). Scattered; along Piceance Creek and irrigation ditches. Astw - native. Grossulariaceae.

TABLE II D-15
(continued)

Rosa woodsii Lindl. Wild Rose. (N). Occasional; draws, gulches, and intermittent streams. Asw - native. Rosaceae.

Salix sp. Willow. Salicaceae.

Sarcobatus vermiculatus (Hook.) Torr. Greasewood. (M). Frequent; dense stands present on alluvial fans on the north side of Piceance Creek. Atw - native. Chenopodiaceae.

Shepherdia argentea (Pursh) Nutt. Silver Buffaloberry. (N). Rare; deep gulches along intermittent streams (Sorghum Gulch). Not a rare species in Colorado, but very restricted on C-b. Atw - native. Eleagnaceae.

Symphoricarpos orephilus A. Gray. Snowberry. (N). Common; mixed mountain shrub communities, and as an understory component in pinyon-juniper woodlands. Atw - native. Caprifoliaceae.

Tetradymia canescens DC. Horsebrush. (N). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. More common at higher elevations. Atw - native. Compositae.

Ulmus pumila L. Siberian Elm. (N). Rare; an introduced species much planted for shade. Only one small plant has been noted; an escapee from cultivation. Er - introduced. Ulmaceae.

HERBS

Achillea lanulosa Nutt. Yarrow. (Hsr). As - native. Compositae.

Agoseris glauca (Pursh) Raf. False Dandelion. (Hr). Relatively common; conspicuous in spring in pinyon-juniper woodlands. Atw - native. Compositae.

Agropyron smithii Rydb. Western Wheatgrass. (Grh). Relatively common; sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Gramineae.

Agropyron desertorum (Fisch.) Schult. Crested Wheatgrass. (Hs). Relatively common; chained pinyon-juniper woodlands and other disturbed sites. This species is commonly seeded for range improvement. Er - introduced. Gramineae.

TABLE II D-15
(continued)

-
- Agropyron spicatum (Pursh) Scribn. et Smith. Bluebunch Wheatgrass. (Hs). Frequent; dry colluvial slopes, Indian ricegrass communities, and pinyon-juniper woodlands. Atw - native. Gramineae.
- (?) Agropyron trachycaulum (Link) Malte. Slender Wheatgrass. (Hs). As - native. Gramineae.
- Agrostis gigantea Roth. Red Top. (Hsr). Frequent; irrigated pastures, along irrigation ditches and streams. Cs - native. Gramineae.
- Amaranthus albus L. White Pigweed. (Th). Common; roadsides and disturbed sites. Atw - native. Amaranthaceae.
- Amaranthus retroflexus L. Pigweed. (Th). Occasional; disturbed sites in all communities. Ta - introduced. Amaranthaceae.
- Ambrosia artemisiifolia L. Ragweed. (Th). Frequent; roadsides, along streams, and on disturbed sites. At - native. Compositae.
- Androsace septentrionalis L. Fairy Candelabra. (Th or short-lived Hr). Frequent; open slopes, sagebrush communities. Blooms in early spring. Ca - native. Primulaceae.
- Anemone patens L. See Pulsatilla patens ssp. multifida.
- Antennaria parvifolia Nutt. Pussytoes. (Chp). Frequent; pinyon-juniper and chained pinyon-juniper woodlands. As - native. Compositae.
- Antennaria rosea Greene. Pussytoes. (Chp). Frequent; pinyon-juniper and chained pinyon-juniper woodlands. As - native. Compositae.
- Apocynum androsaemifolium L. Spreading Dogbane. (Hp). Scattered; along intermittent streams in gulches and draws. As - native. Apocynaceae.
- (?) Arabis holboellii Hornem. Rock Cress. (Hs). Scattered; pinyon-juniper woodlands. Flowering in early May. As - native. Cruciferae.
- Artemisia biennis Willd. Biennial Wormwood. (Hs). Occasional; sandy intermittent stream sides and dry channels. At - native. Compositae.

TABLE II D-15
(continued)

-
- Artemisia dracunculus L. ssp. glauca (Pallas) Hall et Clements. Green Sage. (Hs). Frequent; dry colluvial slopes and Indian ricegrass communities. Atw - native. Compositae.
- Artemisia frigida Willd. Pasture Sage. (Hp or Ch). Frequent; dry colluvial slopes and Indian ricegrass communities. Cas - native. Compositae.
- Artemisia ludoviciana Nutt. Sagewort. (Ch). Frequent; dry colluvial slopes and Indian ricegrass communities. At - native. Compositae.
- Asclepias speciosa Torr. Showy Milkweed. (Grh). Atw - native. Asclepiadaceae.
- (?) Aster fendleri A. Gray. Aster. (Hp). Atw - native. Compositae.
- Aster frondosus (Nutt.) T. et G. See Brachyactis frondosa.
- (?) Aster glaucodes Blake. Glaucous Aster. (Hp). Atw - native. Compositae.
- Astragalus kentrophyta A. Gray. Kentrophyta Milk Vetch. (Hp). Frequent; exposed soil on steep slopes, weathered sandstone and disturbed sites. Atw - native. Leguminosae.
- Balsamorhiza sagitta (Pursh) Nutt. Balsam Root. (Hr). Frequent; pinyon-juniper woodlands. Astw - native. Compositae.
- Beckmannia syzigachne (Steud.) Fernald. Sloughgrass. (Th). Scattered; along Piceance Creek and possibly other more permanent water sources. As - native. Gramineae.
- Bouteloua gracilis (H.B.K.) Lag. Blue Grama. (Hsr). Relatively common; pinyon-juniper and chained pinyon-juniper woodlands. Atw - native. Gramineae.
- (?) Brachyactis frondosa (Nutt.) A. Gray. Short-rayed Alkali Aster. (Th). Atw - native. Compositae. (Syn. = Aster frondosus).
- Brickellia grandiflora (Hook.) Nutt. Tassel Flower Brickellbrush. (Hs). Scattered; heads of draws and on colluvial deposits in gulches. Atw - native. Compositae.

TABLE II D-15
(continued)

-
- (?) Bromus porteri (Coult.) Nash. Nodding Brome. (Hs). Scattered; along stream courses in dry gulches. Atw - native. Gramineae. (Syn. * Bromus anomalus Rupr. ex Fourn).
- Bromus inermis Leyss. Smooth Brome. (Hsr). Scattered; along streams and irrigation ditches. Er - introduced. Gramineae.
- Bromus japonicus Thunb. Japanese Brome. (Th). Scattered; chained pinyon-juniper woodlands and disturbed sites. Er - introduced. Gramineae.
- Bromus tectorum L. Cheatgrass. (Th). Common; occurs in all communities, but is more frequent in sagebrush and valley floor communities. Ep - introduced. Gramineae.
- Calochortus gunnisoni S. Wats. Mariposa Lily. (Gb). Rare; chained pinyon-juniper woodlands and ridgetop sagebrush communities. Atw - native. Liliaceae.
- Calochortus nuttallii Torr. Mariposa Lily. (Gb). Frequent; ridgetop sagebrush communities. More common than the previous species. Atw - native. Liliaceae.
- Calylophus hartwegii (Benth.) Raven ssp. lavandulifolius (T. et G.) Towner et Raven. Evening Primrose. (Hp). Occasional; chained pinyon-juniper woodlands. Atw - native. Onagraceae. (Syn. * Oenothera lavandulaefolia).
- Camelina microcarpa Andrz. False Flax. (Th). Scattered; valley pastures and disturbed sites. Ep - introduced. Cruciferae.
- (?) Castilleja chromosa A. Nels. Indian Paintbrush. (Gp). Occasional; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Scrophulariaceae.
- Castilleja linariaefolia Benth. in DC. Indian Paintbrush. (Gp). Frequent; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Scrophulariaceae.
- Chamaesyce sp. Spurge. Euphorbiaceae.
- Chenopodium fremontii S. Wats. Goosefoot. (Th). Occasional; chained pinyon-juniper woodlands and disturbed sites. Atw - native. Chenopodiaceae.

TABLE II D-15
(continued)

Chenopodium sp. Goosefoot. Chenopodiaceae.

Chrysopsis villosa (Pursh) Nutt. ex DC. See Heterotheca villosa.

Cirsium arvense (L.) Scop. Canada Thistle. (Gr). Er - introduced.
Compositae.

Cirsium sp. Thistle. Compositae.

Clematis hirsutissima Pursh. Sugarbowls. (Hp). Rare; mixed mountain shrub communities on north-facing slopes. Not a rare species in Colorado, but known from only one location on C-b (Grid W66, N64). Atw - native. Ranunculaceae.

Cleome serrulata Pursh. Bee Plant. (Th). Common; roadsides, disturbed sites, and dry washes. Atw - native. Capparidaceae.

Comandra umbellata (L.) Nutt. ssp. pallida (A.DC.) Piehl. Bastard Toadflax. (Grh). Frequent; chained pinyon-juniper and ridgetop sagebrush communities. Ast - native. Santalaceae.

Conyza canadensis (L.) Cronquist. Horseweed. (Th). Scattered; disturbed sites, and roadsides. Ast - native. Compositae.

Corydalis aurea Willd. Golden Smoke. (Hp). Occasional; steep sandy slopes and dry washes. As - native. Fumariaceae.

Cryptantha sp. Miner's Candle. Boraginaceae.

Dactylis glomerata L. Orchard Grass. (Hs). Scattered; pastures and hay meadows. Er - introduced. Gramineae.

Delphinium nelsoni Greene. Larkspur. (Grt). Occasional; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Astw - native. Ranunculaceae.

Descurainia pinnata (Walt.) Britt. Tansy Mustard. (Th). Common; disturbed sites in all communities. A highly variable species, with 7 ssp. present in Colorado. Ast - native. Cruciferae.

Echinochloa crus-galli (L.) Beauv. var. mitis (Pursh) Peterm. Barnyard Grass. (Th). Scattered; disturbed sites in pastures, meadows, roadsides, and along streams. Er - introduced. Gramineae.

Elymus cinereus Scribn. et Merr. Great Basin Wildrye. (Hsr). Frequent; valley sagebrush communities and heads of draws. At one time this species was more widespread, but conversion of floodplains to irrigated hay meadows has reduced its abundance. Atw - native. Gramineae.

Epilobium sp. Fireweed. Onagraceae.

Equisetum arvense L. Horsetail. (Grh - life forms are usually not given for cryptogams). Occasional; along Piceance Creek and irrigation ditches. Ca - native. Equisetaceae.

(?) Equisetum hyemale L. Scouring Rush. (Grh - life forms are usually not given for cryptogams). Scattered; along Piceance Creek. Ast - native. Equisetaceae.

Equisetum kansanum Schaffner. See Equisetum laevigatum.

Equisetum laevigatum A. Br. Scouring Rush. (Grh - life forms are usually not given for cryptogams). Occasional; along Piceance Creek and other relatively permanent water bodies. Atw - native. Equisetaceae. (Syn. = Equisetum kansanum).

Erigeron utahensis A. Gray. Utah Daisy Fleabane. (Hp). Occasional; chained pinyon-juniper woodlands and ridgetop sagebrush communities. Atw - native. Compositae.

Eriogonum alatum Torr. Winged Eriogonum. (Hr). Occasional; pinyon-juniper woodlands and exposed outcrops. Atw - native. Polygonaceae.

Eriogonum crenuum Nutt. Nodding Eriogonum. (Th). Occasional; pastures, roadsides, and other disturbed sites. Astw - native. Polygonaceae.

(?) Eriogonum flexum M.E. Jones. Eriogonum. Scattered; disturbed sites and steep slopes. Atw - native. Polygonaceae.

Eriogonum umbellatum Torr. Sulphur Flower. (Hr). Scattered; mixed mountain shrub, more abundant on north-facing slopes. Atw - native. Polygonaceae.

TABLE II D-15
(continued)

-
- Euphorbia robusta (Engelm.) Small. Spurge. (Hp). Scattered; dry colluvial slopes and Indian ricegrass communities. Atw - native. Euphorbiaceae.
- Festuca brachyphylla Schultes. Sheep Fescue. (Hs). Occasional; pinyon-juniper woodlands and chained pinyon-juniper woodlands. Er - introduced. Gramineae.
- Galium coloradoensis W.F. Wright. Colorado Bedstraw. (Hp). Scattered; steep dry colluvial slopes and Indian ricegrass communities. Atw - native. Rubiaceae.
- (?) Gayophytum ramosissimum T. et G. Much-branched Gayophytum. (Th). Scattered; along Piceance Creek and other relatively permanent water bodies. Atw - native. Onagraceae.
- Gilia aggregata (Pursh) Spreng. See Ipomopsis aggregata.
- Glycyrrhiza lepidota Pursh. Wild Licorice. (Hp). Frequent; along Piceance Creek and irrigation ditches. Atw - native. Leguminosae.
- Haplopappus nuttallii T. et G. Goldenweed. (Hp). Occasional; pinyon-juniper and chained pinyon-juniper woodlands. Astw - native. Compositae.
- Grindelia squarrosa (Pursh) Dunal. Curly-cup Gumweed. (Hp). Frequent; roadsides and other disturbed sites. Atw - native. Compositae.
- Hedysarum boreale Nutt. Sweet Vetch. (Hp). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Asa - native. Leguminosae.
- Helianthus annuus L. Common Sunflower. (Th). Frequent; roadsides and disturbed sites. Atw - native. Compositae.
- Helianthus nuttallii T. et G. Nuttall's Sunflower. (Hp). Occasional; along Piceance Creek and irrigation ditches. Atw - native. Compositae.
- Heterotheca villosa (Pursh) Shinnars. Golden Aster. (Hp). Relatively common; present in most communities on C-b but is uncommon in valley sagebrush communities. Atw - native. Compositae. (Syn. = Chrysopsis villosa).

TABLE II D-15
(continued)

-
- Heuchera parvifolia Nutt. ex T. et G. Alumroot. (Hr). Occasional; mixed mountain shrub communities and draws and gulches. Atw - native. Saxifragaceae.
- Hordeum jubatum L. Foxtail Barley. (Hs). Occasional; valley sagebrush communities and moist meadows. Asa - native. Gramineae.
- Ipomopsis aggregata (Pursh) V. Grant. Scarlet Gilia. (Hs). Relatively common; roadsides, dry washes, and pinyon-juniper woodlands. Atw - native. Polemoniaceae. (Syn. = Gilia aggregata).
- Iva xanthifolia Nutt. Marsh Elder. (Th). Common; along Piceance Creek and irrigation ditches. Atw - native. Compositae.
- Juncus arcticus Willd. ssp. ater (Rydb.) Hulten. Baltic Rush. (Grh). Scattered; marshes and along Piceance Creek and irrigation ditches. As - native. Juncaceae. (Syn. = Juncus balticus).
- Juncus balticus Willd. See Juncus arcticus ssp. ater.
- Koeleria cristata (L.) Pers. See Koeleria gracilis.
- Koeleria gracilis Pers. Junegrass. (Hs). Relatively common; ridge-top sagebrush communities and chained pinyon-juniper woodlands. Ct - native. Gramineae. (Syn. = Koeleria cristata).
- Lactuca pulchella (Pursh) DC. See Lactuca tatarica ssp. pulchella.
- Lactuca serriola L. Prickly Lettuce. (Th). Occasional; roadsides and disturbed sites. Ep - introduced. Compositae. (Syn. = Lactuca scariola).
- Lactuca tatarica (L.) C.A. May ssp. pulchella (Pursh) Stebbins. Blue Lettuce. (Hs). Scattered; mixed mountain shrub communities and rarely along roadsides. As - native. Compositae. (Syn. = Lactuca pulchella).
- Lappula redowskii (Hornem.) Greene. Stickseed. (Th). Relatively common; pastures, valley sagebrush communities, and chained pinyon-juniper woodlands. Asw - native. Boraginaceae.

TABLE II D-15
(continued)

-
- Lepidium montanum Nutt. Mountain Peppergrass. (Hs). Common; valley sagebrush communities, disturbed sites, and occasionally in mixed mountain shrub communities. Atw - native. Cruciferae.
- Lepidium perfoliatum L. Peppergrass. (Th). Frequent; pastures and heavily grazed sites. Ep - introduced. Cruciferae.
- Linum lewisii Pursh. Wild Flax. (Hp). Frequent; dry colluvial slopes and Indian ricegrass communities. Aa - native. Linaceae.
- Lithospermum sp. Puccoon. Boraginaceae.
- Lolium perenne L. Darnel. (Hs). Relatively rare; disturbed sites. A species introduced in the area; possibly mixed with other grass seed. Ep - introduced. Gramineae.
- (?) Lupinus argenteus Pursh. Lupine. (Hp). Atw - native. Leguminosae.
- Lupinus sp. Lupine. Leguminosae.
- Lygodesmia grandiflora (Nutt.) T. et G. Skeletonweed. (Gr). Scattered; dry slopes and pinyon-juniper woodlands. Atw - native. Compositae.
- Malcolmia africana (L.) R. Br. Malcolmia. (Th). Common; roadsides and disturbed sites, especially around farm buildings. Blooms in very early spring. Af - introduced. Cruciferae.
- Medicago sativa L. Alfalfa. (Hp). Abundant; this species is planted as a hay crop in the meadows along Piceance Creek, Willow Creek, and Stewart Creek. Er - introduced. Leguminosae.
- Melilotus alba Desr. White Sweet Clover. (Hs). Frequent; along streams and dry washes. Occasionally along roadsides. Ep - introduced. Leguminosae.
- Melilotus officinalis (L.) Lam. Yellow Sweet Clover. (Hs). Frequent; along streams and dry washes, occasionally along roadsides. Ep - introduced. Leguminosae.
- Mentzelia rusbyi Wooton. Evening Star. (Grt). Occasional; dry colluvial slopes and roadsides. Atw - native. Loasaceae. (Syn. = Mentzelia nuda var. rusbyi).

TABLE II D-15
(continued)

-
- Mentzelia sp. Evening Star. Loasaceae.
- Mirabilis linearis (Pursh) Heimerl. See Oxybaphus linearis.
- Nasturtium officinale R. Br. See Rorippa pasturtium-aquaticum.
- Oenothera caespitosa Nutt. ex Fraser. Gumbo Lily. (Hr). Occasional;
steep roadsides and disturbed sites. Atw - native. Onagraceae.
- Oenothera lavandulaefolia T. et G. See Calylophus hartwegii ssp.
lavandulifolius.
- Oenothera sp. Evening Primrose. Onagraceae.
- Oenothera strigosa (Rydb.) Mack et Bush. Yellow Evening Primrose.
(Hs). Scattered; along Piceance Creek and other moist areas.
At - native. Onagraceae.
- Oenothera trichocalyx Nutt. ex T. et G. Evening Primrose. (Hs).
Rare; dry washes and alluvial deposits. Atw - native. Onagraceae.
- Onosmodium molle Michx. var. occidentalis (Mack.) Johnston. False
Gromwell. (Hs). Scattered; roadsides and dry slopes. At - native.
Boraginaceae.
- Oryzopsis hymenoides (R. et S.) Ricker. Indian Ricegrass. (Hs).
Common; dry colluvial slopes and chained pinyon-juniper woodlands.
Atw - native. Gramineae.
- Oryzopsis micrantha (Trin. et Rupr.) Thurber. Little Ricegrass. (Hs).
Scattered; pinyon-juniper woodlands and valley sagebrush communi-
ties. Atw - native. Gramineae.
- Oxybaphus linearis (Pursh) Robbins. Umbrellawort. (Hp). Scattered;
sandy ridges and slopes. Atw - native. Nyctaginaceae. (Syn. =
Mirabilis linearis).
- Penstemon sp. Beard Tongue. Scrophulariaceae.
- (?) Phacelia idahoensis Henderson. Phacelia. (Hp). Occasional; pinyon-
juniper woodlands and roadsides. Atw - native. Hydrophyllaceae.

TABLE II D-15
(continued)

Phleum pratense L. Timothy. (Hs). Frequent; hay meadows and pastures.
Er - introduced. Gramineae.

- (?) Phlox hoodii Rich. Moss Phlox. (Chcp). Common; pinyon-juniper woodlands, ridgetop sagebrush communities, and chained pinyon-juniper woodlands. Asw - native. Polemoniaceae.

Phlox longifolia Nutt. Long-leaved Phlox. (Hp). Frequent; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Polemoniaceae.

Phragmites australis (Cav.) Trin. ex Steud. Common Reed. (Hsr). Common; marshes and along Piceance Creek. Restricted to wet environments. Cst - native. Gramineae. (Syn. = Phragmites communis).

Phragmites communis Trin. See Phragmites australis.

Physaria floribunda Rydb. Double Bladderpod. (Hr). Frequent; steep slopes, dry washes, and pinyon-juniper woodlands. Atw - native. Cruciferae.

Poa fendleriana (Steud.) Vasey. Muttongrass. (Hs). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Gramineae.

Poa pratensis L. Kentucky Bluegrass. (Grh). Frequent; meadows, pastures, and along streams and irrigation ditches. Cas - introduced. Gramineae.

Polypogon monspeliensis (L.) Desf. Rabbit's-foot Grass. (Th). Scattered; along streams and irrigation ditches. Ep - introduced. Gramineae.

- (?) Potentilla gracilis Dougl. ex Hook. Cinquefoil. (Hs). Relatively rare; sheltered gulches along rocky intermittent streams. Asw - native. Rosaceae.

Pulsatilla patens (L.) Mill. ssp. multifida (Pritzel) Zamels. Pasque Flower. (Hs). Rare; north-facing mountain shrub communities. Not rare in Colorado, but very restricted on Tract C-b. Ranunculaceae.

TABLE II D-15
(continued)

Ranunculus cymbalaria Pursh. Shore Buttercup. (Hsr). Scattered;
wet sandy and streamside deposits along Piceance Creek. Ca -
native. Ranunculaceae.

Rorippa nasturtium-aquaticum (L.) Schinz et Thell. Watercress. (HH).
Scattered; in streams and shallow water, Stewart Creek. Ep -
introduced. Cruciferae. (Syn. = Nasturtium officinale).

Rumex sp. Dock. Polygonaceae.

Salsola iberica Sennen et Pau. Russian Thistle. (Th). Common;
roadsides and disturbed sites. Er - introduced. Chenopodiaceae.
(Syn. = Salsola kali var. tenuiflora).

Salsola kali L. var. tenuiflora Tausch. See Salsola iberica.

Scirpus lacustris L. ssp. validus (Vahl) Koyama. Tule. (Grh).
Scattered; along Piceance Creek and other relatively permanent
streams. As - native. Cyperaceae. (Syn. = Scirpus validus).

Scirpus paludosus A. Nels. Prairie Bulrush. (Grh). Scattered;
along Piceance Creek and other relatively permanent streams.
Atw - native. Cyperaceae.

Scirpus validus Vahl. See Scirpus lacustris ssp. validus.

Senecio eremophilus Rydb. var. kingii (Rydb.) Greenm. Ragwort. (Hp).
Occasional; chained pinyon-juniper woodlands. Atw - native.
Compositae.

Senecio multilobatus T. et G. ex A. Gray. Golden Ragwort. (Grh).
Occasional; pinyon-juniper and chained pinyon-juniper woodlands.
Atw - native. Compositae.

Sidalcea neomexicana A. Gray. Checker Mallow. (Hp). Occasional;
hay meadows and pastures along Piceance Creek. Atw - native.
Malvaceae.

Sisymbrium altissimum L. Tumble Mustard. (Th). Relatively common;
chained pinyon-juniper woodlands and disturbed sites. Ep -
introduced. Cruciferae.

Sitanion hystrix (Nutt.) J.G. Smith. See Sitanion longifolium.

TABLE II D-15
(continued)

-
- Sitanion longifolium J.G. Smith. Squirreltail Grass. (Hs). Frequent; sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Gramineae. (Syn. = Sitanion hystrix).
- Smilacina stellata (L.) Desf. False Solomon's Seal. (Grh). Relatively rare; Douglas-fir forests. As - native. Liliaceae.
- Solidago canadensis L. Meadow Goldenrod. (Hsr). Scattered; along Piceance Creek. Ast - native. Compositae.
- (?) Solidago sparsiflora A. Gray. Goldenrod. (Hsr). Scattered; along intermittent streams in draws and gulches. Atw - native. Compositae.
- (?) Sonchus arvensis L. Sow Thistle. (Hsr). Scattered; meadows and pastures along Piceance Creek. Ep - introduced. Compositae.
- Sphaeralcea coccinea (Pursh) Rydb. Scarlet Globe Mallow. (Hp). Common; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Malvaceae.
- (?) Sporobolus cryptandrus (Torr.) A. Gray. Sand Dropseed. (Hsr). Scattered; roadsides and sandy alluvial deposits. At - native. Gramineae.
- Stipa comata Trin. et Rupr. Needle-and-Thread Grass. (Hs). Frequent; sagebrush communities and chained pinyon-juniper woodlands. Astw - native. Gramineae.
- Streptanthus cordatus Nutt. ex T. et G. Twistflower. (Hs). Scattered; pinyon-juniper woodlands and chained pinyon-juniper woodlands. Atw - native. Cruciferae.
- Taraxacum officinale Web. in Wiggers. Dandelion. (Hr). Frequent; roadsides and disturbed sites. Er - introduced. Compositae.
- (?) Townsendia hookeri Beaman. Easter Daisy. (Hr). Frequent; ridgetop sagebrush communities, pinyon-juniper and chained pinyon-juniper woodlands. Atw - native. Compositae.
- Townsendia incana Nutt. Easter Daisy. (Hr). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Compositae.

TABLE II D-15
(concluded)

-
- Tragopogon dubius Scop. Goat's Beard. (Hs). Occasional; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Ep - introduced. Compositae.
- Trifolium gymnocarpon Nutt. Clover. (Hs). Relatively rare; pinyon-juniper woodlands and mixed mountain shrub communities. Atw - native. Leguminosae.
- Triglochin maritima L. Seaside Arrowgrass. (Hr). Relatively rare; marshes and moist meadows along Piceance Creek and other streams. Cas - native. Juncaginaceae.
- Tripterocalyx micranthus (Torr.) Hook. Wing-fruited Sand Verbena. (Th). Rare; sandy alluvial deposits. Atw - native. Nyctaginaceae.
- Typha latifolia L. Cattail. (HH). Frequent; marshes and streamsides. Restricted to wet environments. As - native. Typhaceae.
- Urtica dioica L. Stinging Nettle. (Hpr). Scattered; moist meadows in draws and gulches. As - native. Urticaceae.
- Veronica salina Schur. Speedwell. (Hp). Scattered; streamside sites along Piceance Creek. Ct - native. Scrophulariaceae.
- Yucca glauca Nutt. Yucca. (Hr). Occasional; chained pinyon-juniper woodlands. Atw - native. Liliaceae.
- Zigadenus venenosus S. Wats. var. gramineus (Rydb.) Walsh ex M.E. Peck. Death Camas. (Gb). Scattered; ridgetop sagebrush communities and chained pinyon-juniper woodlands. Atw - native. Liliaceae.
-

(?) Specific species identification in doubt.

TABLE II D-16

ALPHABETICAL LISTING OF COMMON NAMES FOR THE FLORA OF TRACT C-b

Common Name	Scientific Name(s)
TREES, SHRUBS, AND VINES	
Antelope bitterbrush	<u>Purshia tridentata</u>
Big sagebrush	<u>Artemisia tridentata</u>
Blue clematis	<u>Clematis columbiana</u>
Box elder	<u>Acer negundo</u>
Chokecherry	<u>Prunus virginiana</u> var. <u>melanocarpa</u>
Currant	<u>Ribes cereum</u>
Douglas fir	<u>Pseudotsuga menziesii</u>
Four-winged saltbush	<u>Atriplex canescens</u>
Gambel oak	<u>Quercus gambelii</u>
Golden currant	<u>Ribes aureum</u>
Greasewood	<u>Sarcobatus vermiculatus</u>
Horsebrush	<u>Tetradymia canescens</u>
Mormon tea	<u>Ephedra viridis</u>
Mountain mahogany	<u>Cercocarpus montanus</u>
Narrow-leaf cottonwood	<u>Populus angustifolia</u>
Oregon grape	<u>Mahonia repens</u>
Pinyon pine	<u>Pinus edulis</u>
Prickly pear	<u>Opuntia polyacantha</u>
Rabbitbrush	<u>Chrysothamnus viscidiflorus</u>
Rock spirea	<u>Holodiscus dumosus</u>
Rocky mountain juniper	<u>Juniperus scopulorum</u>
Rubber rabbitbrush	<u>Chrysothamnus nauseosus</u>
Serviceberry	<u>Amelanchier alnifolia</u>
Shadscale	<u>Atriplex confertifolia</u>
Siberian elm	<u>Ulmus pumila</u>
Silver buffaloberry	<u>Shepherdia argentea</u>
Skunkbush	<u>Rhus trilobata</u>

Smooth currant	<u>Ribes inerme</u>
Snakeweed	<u>Gutierrezia sarothrae</u>
Snowberry	<u>Symphoricarpos orephilus</u>
Utah juniper	<u>Juniperus osteosperma</u>
Western virgin's-bower	<u>Clematis ligusticifolia</u>
Wild buckwheat	<u>Eriogonum lonchophyllum</u>
Wild hops	<u>Humulus lupulus</u> var. <u>neomexicanus</u>
Wild rose	<u>Rosa woodsii</u>
Willow	<u>Salix</u> sp.
Winter fat	<u>Ceratoides lanata</u>
HERBS	
Alfalfa	<u>Medicago sativa</u>
Alumroot	<u>Heuchera parvifolia</u>
Aster	<u>Aster</u> sp.
Balsam root	<u>Balsamorhiza sagittata</u>
Baltic rush	<u>Juncus arcticus</u> ssp. <u>ater</u>
Barnyard grass	<u>Echinochloa crus-galli</u> var. <u>mitis</u>
Bastard toadflax	<u>Comandra pallida</u> ssp. <u>umbellata</u>
Beard tongue	<u>Penstemon</u> sp.
Bee plant	<u>Cleome serrulata</u>
Biennial wormwood	<u>Artemisia biennis</u>
Blue-bunch wheatgrass	<u>Agropyron spicatum</u>
Blue grama	<u>Bouteloua gracilis</u>
Blue lettuce	<u>Lactuca tatarica</u> ssp. <u>pulchella</u>
Canada thistle	<u>Cirsium arvense</u>
Cattail	<u>Typha latifolia</u>
Cheatgrass	<u>Bromus tectorum</u>
Checker mallow	<u>Sidalcea neomexicana</u>
Cinquefoil	<u>Potentilla gracilis</u>
Clover	<u>Trifolium gymnocarpon</u>
Colorado bedstraw	<u>Galium coloradoensis</u>

TABLE II D-16
(continued)

Common reed	<u>Phragmites australis</u>
Common sunflower	<u>Helianthus annuus</u>
Crested wheatgrass	<u>Agropyron desertorum</u>
Curly-cup gumweed	<u>Grindelia squarrosa</u>
Dandelion	<u>Taraxacum officinale</u>
Darnel	<u>Lolium perenne</u>
Death camas	<u>Zigadenus venenosus</u> var. <u>gramineus</u>
Dock	<u>Rumex</u> sp.
Double bladderpod	<u>Phvsaria floribunda</u>
Easter daisy	<u>Townsendia hookeri</u> , <u>Townsendia incana</u>
Eriogonum	<u>Eriogonum flexum</u>
Evening primrose	<u>Calylophus hartwegii</u> ssp. <u>lavandulifolius</u> , <u>Oenothera trichocalyx</u> , <u>Oenothera</u> sp.
Evening star	<u>Mentzelia rusbyi</u> , <u>Mentzelia</u> sp.
Fairy candelabra	<u>Androsace septentrionalis</u>
False dandelion	<u>Agoseris glauca</u>
False flax	<u>Camelina microcarpa</u>
False gromwell	<u>Onosmodium molle</u> var. <u>occidentalis</u>
False Solomon's seal	<u>Smilacina stellata</u>
Fireweed	<u>Epilobium</u> sp.
Foxtail barley	<u>Hordeum jubatum</u>
Glaucous aster	<u>Aster glaucodes</u>
Goat's beard	<u>Tragopogon dubius</u>
Golden aster	<u>Heterotheca villosa</u>
Golden ragwort	<u>Senecio multilobatus</u>
Goldenrod	<u>Solidago sparsiflora</u>
Golden smoke	<u>Corydalis aurea</u>
Goldenweed	<u>Haplopappus nuttallii</u>
Goosefoot	<u>Chenopodium fremontii</u> , <u>Chenopodium</u> sp.
Great Basin wildrye	<u>Elymus cinereus</u>
Green sage	<u>Artemisia dracunculus</u> ssp. <u>glauca</u>
Gumbo lily	<u>Oenothera caespitosa</u>
Horsetail	<u>Equisetum arvense</u>

TABLE II D-16
(continued)

Horseweed	<u>Conyza canadensis</u>
Indian paintbrush	<u>Castilleja chromosa</u> , <u>Castilleja linariaefolia</u>
Indian ricegrass	<u>Oryzopsis hymenoides</u>
Japanese brome	<u>Bromus japonicus</u>
Junegrass	<u>Koeleria gracilis</u>
Kentrophyta milk vetch	<u>Astragalus kentrophyta</u>
Kentucky bluegrass	<u>Poa pratensis</u>
Larkspur	<u>Delphinium nelsoni</u>
Little ricegrass	<u>Oryzopsis micrantha</u>
Long-leaved phlox	<u>Phlox longifolia</u>
Lupine	<u>Lupinus argenteus</u> , <u>Lupinus</u> sp.
Malcolmia	<u>Malcolmia africana</u>
Mariposa lily	<u>Calochortus gunnisoni</u> , <u>Calochortus nuttallii</u>
Marsh elder	<u>Iva xanthifolia</u>
Meadow goldenrod	<u>Solidago canadensis</u>
Miner's candle	<u>Cryptantha</u> sp.
Moss phlox	<u>Phlox hoodii</u>
Mountain peppergrass	<u>Lepidium montanum</u>
Much-branched gayophytum	<u>Gayophytum ramosissimum</u>
Mutton grass	<u>Poa fendleriana</u>
Needle-and-thread grass	<u>Stipa comata</u>
Nodding brome	<u>Bromus porteri</u>
Nodding eriogonum	<u>Eriogonum cernuum</u>
Nuttall's sunflower	<u>Helianthus nuttallii</u>
Orchard grass	<u>Dactylis glomerata</u>
Pasque flower	<u>Pulsatilla patens</u> ssp. <u>multifida</u>
Pasture sage	<u>Artemisia frigida</u>
Peppergrass	<u>Lepidium perfoliatum</u>
Phacelia	<u>Phacelia idahoensis</u>
Pigweed	<u>Amaranthus retroflexus</u>
Prairie bulrush	<u>Scirpus paludosus</u>
Prickly lettuce	<u>Lactuca serriola</u>

TABLE II D-16
(continued)

Puccoon	<u>Lithospermum</u> sp.
Pussytoes	<u>Antennaria rosea</u> , <u>Antennaria parvifolia</u>
Rabbit's-foot grass	<u>Polypogon mousPELLIENSIS</u>
Ragweed	<u>Ambrosia artemisiifolia</u>
Ragwort	<u>Senecio eremophilus</u> var. <u>kingii</u>
Red top	<u>Agrostis gigantea</u>
Rock cress	<u>Arabis holboellii</u>
Russian thistle	<u>Salsola iberica</u>
Sagewort	<u>Artemisia ludoviciana</u>
Sand dropseed	<u>Sporobolus cryptandrus</u>
Scarlet gilia	<u>Ipomopsis aggregata</u>
Scarlet globe mallow	<u>Sphaeralcea coccinea</u>
Scouring rush	<u>Equisetum hyemale</u> , <u>Equisetum laevigatum</u>
Seaside arrowgrass	<u>Triglochin maritima</u>
Sheep fescue	<u>Festuca brachyphylla</u>
Shore buttercup	<u>Ranunculus cymbalaria</u>
Short-rayed alkali aster	<u>Brachyactis frondosa</u>
Showy milkweed	<u>Asclepias speciosa</u>
Skeletonweed	<u>Lygodesmia grandiflora</u>
Slender wheatgrass	<u>Agropyron trachycaulum</u>
Sloughgrass	<u>Beckmannia syzigachne</u>
Smooth brome	<u>Bromus inermis</u>
Sow thistle	<u>Sonchus arvensis</u>
Speedwell	<u>Veronica salina</u>
Spreading dogbane	<u>Apocynum androsaemifolium</u>
Spurge	<u>Chamaesyce</u> sp., <u>Euphorbia robusta</u>
Squirreltail grass	<u>Sitanion longifolium</u>
Stickseed	<u>Lappula redowskii</u>
Stinging nettle	<u>Urtica dioica</u>
Sugarbowls	<u>Clematis hirsutissima</u>
Sulphur flower	<u>Eriogonum umbellatum</u>
Sweet vetch	<u>Hedysarum boreale</u>
Tansy mustard	<u>Descurainia pinnata</u>

TABLE II D-16
(concluded)

Tassel-flower brickellbrush	<u>Brickellia grandiflora</u>
Thistle	<u>Cirsium sp.</u>
Timothy	<u>Phleum pratense</u>
Tule	<u>Scirpus lacustris ssp. validus</u>
Tumble mustard	<u>Sisymbrium altissimum</u>
Twistflower	<u>Streptanthus cordatus</u>
Umbrellawort	<u>Oxybaphus linearis</u>
Utah daisy fleabane	<u>Erigeron utahensis</u>
Watercress	<u>Rorippa nasturtium-aquaticum</u>
Western wheatgrass	<u>Agropyron smithii</u>
White pigweed	<u>Amaranthus albus</u>
White sweet clover	<u>Melilotus alba</u>
Wild flax	<u>Linum lewisii</u>
Wild licorice	<u>Glycyrrhiza lepidota</u>
Winged eriogonum	<u>Eriogonum alatum</u>
Wing-fruited sand verbena	<u>Tripterocalyx micranthus</u>
Yarrow	<u>Achillea lanulosa</u>
Yellow evening primrose	<u>Oenothera strigosa</u>
Yellow sweet clover	<u>Melilotus officinalis</u>
Yucca	<u>Yucca glauca</u>

In late January of 1975 subsamples of soils collected on Tract C-b were sown with oats and barley. Control flats of vermiculite were also sown. Following germination, 15 individuals from each species from each flat were selected randomly for growth measurements. Initial growth measurements were made 13 days after planting. Measurements taken include: total height, number of leaves, number of nodes, length of leaves, height to nodes, and length of internodes. These measurements were made at weekly intervals. The final measurements will be taken during the week of March 2, 1975. After this measurement sequence, the plants will be harvested. The marked plants used for growth measurements will be weighed individually to obtain shoot and total biomass. Root biomass will be determined for an average plant. The remaining plants will be weighed to obtain root, shoot, and total biomass produced for each soil type. The data will then be statistically analyzed to ascertain differences between the productivity of the various soils as well as between the soils and the controls.

A final report on this part of the soils program will then be prepared and will be included in the appropriate quarterly report when it becomes available.

III A FISH AND WILDLIFE MANAGEMENT PLAN

The Fish and Wildlife Management Plan for Tract C-b will be better defined as more information from the terrestrial wildlife and aquatic studies becomes available. The intensive big game studies which have been taking place during the winter months are expected to be valuable in formulating this Plan. It is important, however, to discuss early in the program the objectives, theories, and philosophies to be incorporated in such a Plan, and these discussions have occupied much of this quarter.

During the second quarter meetings were held with State and Federal game and fish department officials, with recent discussions focusing on the development of a Cooperative Piceance Basin Wildlife Plan, or at least a process for its achievement through proper government agencies. The C-b Shale Oil Project also recognizes the need for in-house coordination between the development engineers and the environmental staff to ensure that the Tract C-b Plan will address the tract-specific impacts that can be expected, and to formulate measures to minimize these impacts. To this end, a dialogue has been initiated among the contractors, operators, environmental staff, engineering staff, and management officers, to alert all groups to the Lease provisions and to the current status in the development of the Fish and Wildlife Management Plan.

III B REVEGETATION PROGRAM

During the second quarter, revegetation planning has continued. It is the intent of the C-b Shale Oil Project to rehabilitate lands disturbed by the development of shale oil resources on Tract C-b in a manner consistent with good ecological practices, economic feasibility, and practical land use considerations.

A Revegetation Program will be developed to:

- a) stabilize and control erosion on disturbed surfaces
- b) support animal populations at least as extensive as those presently on Tract C-b
- c) coordinate the natural processes of ecosystem recovery which occur independent of man with the best available management practices.

Two types of revegetation are important on Tract C-b: (a) the establishment of plant cover on sites disturbed during the exploratory and development phases of the project, and (b) revegetation of spent shale after the mining and retorting operation begins. The first is an immediate need; whereas, the second is a long-term project.

During the second quarter, disturbed areas have been identified for revegetation during the growing season of 1975. Planting procedures will be proposed.

Major site types requiring revegetation of disturbed soils include abandoned drill pads, access roads, and other cleared support sites. The revegetation of these sites follows more conventional techniques than for processed shale disposal sites. These conventional techniques will be evaluated in order to determine their suitability in establishing vegetation for support of wildlife, livestock and other existing animal populations.

III C MICROENVIRONMENTAL PROGRAM

The four continuous recording microenvironmental stations were installed in late February. Stations are located in each of the four major vegetation types on Tract C-b (pinyon-juniper woodland, chained pinyon-juniper woodland, valley bottom sagebrush, and plateau sagebrush). Continuous recordings were begun upon installation. Due to a lag period for instrument and sensor acclimatization, no data are available from the stations at this time. Data should be available for reporting at the end of the next quarter.

In addition to the recording microenvironmental stations, 17 relocatable spot check stations have been established to gather more limited microenvironmental data in a greater range of environments (see Summary Report #1 for details on the types of data gathered for the spot check stations and the recording stations). The spot check stations were established in the last quarter. No data have been interpreted from these sites; however, raw data for snow depth, density, and distribution, and for soil moisture have been included in Quarterly Report #2.

Additional data for the spot check stations and data for the recording stations will be available for the next quarter. Interpretations will not be extensively made until a greater range of data is available.

III D AERIAL PHOTOGRAPHIC STUDY

There are no second quarter activities to report for the aerial photographic study. The February flight, previously scheduled, was cancelled. It was determined that a major flight during the winter was of little value biologically and of no value to geology or engineering. The winter flights made for deer counts will provide sufficient information for other aspects of the biological program. A flight is currently being scheduled for the 1975 growing season.

First flight photography is being used extensively in the soils survey, the terrestrial vegetation studies, and the geological studies.

III E ARCHAEOLOGICAL STUDIES

As part of the environmental studies for Tract C-b, a program of archaeological reconnaissance was undertaken to determine the nature and significance of the cultural resources possibly present on the Tract. The field work was undertaken under the supervision of Dr. Calvin H. Jennings of the Laboratory of Public Archaeology, Colorado State University, operating as a subconsultant under our major environmental consultant, Woodward-Clyde, Envicon Division, San Francisco, California.

Three previously unknown sites were located during the field phase of the project. These three sites and two others adjacent to Tract C-b constitute the resources evaluated in the Final Report of Cultural and Paleontological Resources - Federal Oil Shale Lease Tract C-b, which is contained in Quarterly Report #2. The sites which were located are not seen as being of particularly great significance on either a national or regional level. The lack of significance is based on the comparison of the resources of Tract C-b with those of other portions of the Piceance Basin, where site densities were found to be higher and most sites showed evidence of more intensive occupation than was the case of Tract C-b. The differences in occupational intensity cannot be readily explained from the data derived from this study, however. Hypothetical explanations for these differences are based on the Tract's resource potential for nonindustrial man.

The cultural resources of Tract C-b include, in addition to the three identifiable archaeological sites mentioned above, a number of objects dating from the prehistoric period of occupation which were not found in association with any other archaeological materials. The period of occupation of the Tract vicinity, judging from the artifacts collected from the sites and those found in isolation, falls between about 5000 B.C. and 1879 A.D. None of the sites on the Tract proper produced any evidence of use by peoples having metal tools. The Tract most likely was not intensively used but probably was the site of hunting and gathering. The sites found on the Tract may be briefly described as follows:

5RB136

Located in the northeastern corner of the Tract; there are no visible features present on the site. However, a few fragments of shattered bone were found which had been exposed to intense heating. The site is relatively undisturbed, with a truck trail cutting across its western edge and a dump of modern trash on its southern end. There is no evidence of disturbance of the deposits, and the overall condition of the site is deemed good. The artifact yield was relatively small. Only seven waste flakes were found, indicating that relatively little stone tool manufacture or repair was done there. A single tool was found; it is a bifacially flaked object with no modifications, such as notches, of the blade margins. The absence of diagnostic artifacts from the inventory of the site

makes determination of the age of the occupation or the cultural affinities of the occupants impossible. From the comparison with other sites where similar artifacts have been found, it should be clear that the age of the site could range anywhere from several thousand years to only a few hundred. Sites of this sort seem to be numerous in the region and 5RB136 has been judged to be by no means the best example of the class. Consequently, it has not been recommended for nomination to the National Register of Historic Sites. However, burned bone fragments such as those which were found on this site are frequently found in the fire pits over which preindustrial man cooked his food. Therefore, such features could conceivably be present at this site and would then be exposed by disturbance of the surface. For this reason, it has been recommended that the site be provided some protection during development of other areas of the Tract. In the event that development activity is planned for the immediate areas of the site, test-excavation should take place to ascertain whether preservation of its contents for future generations is warranted.

5RB146

Located in the northeastern portion of the Tract; no features are present at the site and there is no evidence which implies the presence of stationary objects. The ridge top in this area has been chained and the scientific and cultural values of the site have been damaged severely. A pinyon-juniper copse was left standing around a quarter-section monument, but in general, outside the protected area near the monument, the site is in very poor condition. A truck trail passes on the western side of the site. Three waste flakes were found in the area, indicating rather limited use of the site. Two projectile points were also found at the site, as well as a scraper fragment. There is no evidence from the site which indicates what the cultural ties of its inhabitants may have been. The site has been judged to have a low potential value either as a source of information or as an example of the kind of settlement occupied during the middle portion of the Archaic Period, to which it has been assigned. The site warrants, as nearly as can be estimated from the surface collections, neither nomination to the National Register nor intensive excavation. However, it has been recommended that, if the portion of this site which is within the undisturbed area around the quarter-section marker is to be altered by development activities, limited testing be carried out to verify the assumptions made during this reconnaissance.

5RB147

Located near the northwestern corner of the Tract; no stationary cultural objects were observed at the site, nor was there any other evidence to indicate that fire pits,

house floors, or storage structures could be present. Because this area has been subjected to chaining, much of the site has been extensively disturbed and is considered to have been destroyed. The site produced four waste flakes and a small fragment of the blade of a knife or projectile point. The lack of diagnostic cultural material precludes either the determination of the cultural ties of the former occupants of the site or the time of that occupation. It has been judged to be of no scientific value or historical significance and should not be nominated to the National Register.

The following types of objects were found on the Tract at areas other than the above-described sites: three projectile points; four chipped stone tools; and three ground stone tools.

The sites which were found off-Tract are the following:

5RB69

Located north of the Tract boundary; six flakes comprise the total artifactual yield of the site, which has been disturbed by modern uses. The site has been judged to have neither scientific value nor historic or cultural significance.

5RB67

Located just outside the southeastern extremity of the Tract; the site consists of a cement-chinked log cabin, a dugout, and a thin scatter of historic trash. An abandoned irrigation ditch also crosses the site. The site can be said to be in poor condition, and there are numerous such sites scattered over the region, many of which are in better condition and have longer periods of occupation than this site.

From the foregoing evidence it has been assumed that the Tract C-b area was only lightly occupied. Comparison of the Tract localities with those of the Stake Springs vicinity or of lower Duck Creek (C. H. Jennings, in press), indicates that the area was evidently not on the list of preferred camping localities during prehistory. The reasons for this expression of preference are not yet clear. The Tract locality seems to be well endowed with natural resources and a paucity of subsistence resources cannot explain the low density of occupation. Further analysis of the settlement patterns in the more heavily utilized parts of the basin is necessary before we can go further toward trying to find an explanation.

Another consideration may also need to be investigated with respect to the low site density on Tract C-b. The chaining of the pinyon-juniper in this locality has probably had deleterious effects on the rather fragile archaeological sites. It may be that some of the evidence of prehistoric activity was rendered unrecoverable during the range of improvement program.

The paleontological resources in the Tract C-b area, as discovered to this point, are represented by a finding of several mammalian fossil bones off-Tract. These are presently being examined by a trained paleontologist for identification.

III F SCENIC VALUES PROGRAM

During the second quarter, photographic documentation (mainly 35 mm slides, some movie footage) continued on the Tract and surrounding area. This documentation is providing a record of baseline conditions which will be useful for the Scenic Values Program. Stations have been marked at fixed locations for periodic photographs to show changes with time and seasons. The station sites include both over-view and localized coverage.

Specific activities also are being photographed such as various environmental studies and exploration work in order to consider mitigation of potential impacts. Sites for these photographs are chosen on the basis of their position as focal points of continuing activity.

Several alternate approaches for more fully evaluating the aesthetic resources of the Tract area are being investigated. Approaches are being considered based on the applicability of the method to evaluating the characteristics of the Tract and its surrounding area, as well as the usefulness of the approach for input of the scenic values into the development phases of the project.

Form 1279-3
(June 1964)

BORROWER

TN 859 - C64 C37
C-b Shale Oil P
Tract C-b: sum

DATE LOANED	BORROWER

USDI - ELM

